MACHINERY.

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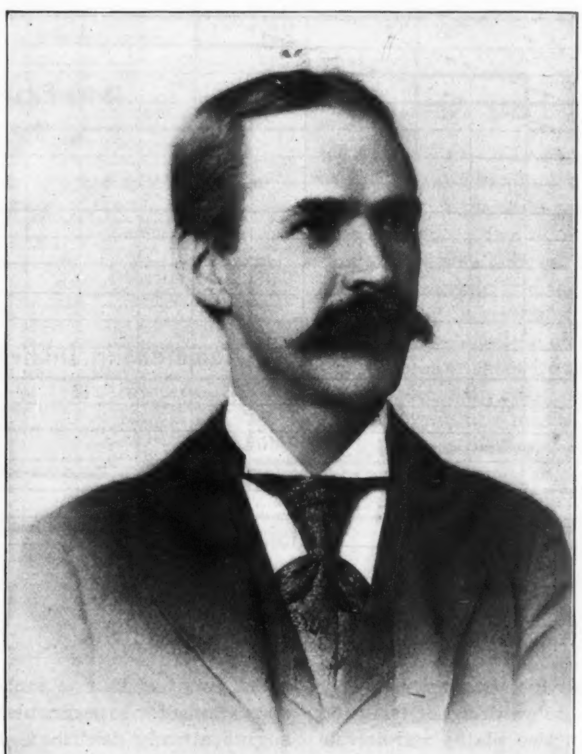
STANDARD FITS IN THE MACHINE SHOP.

ARTHUR A. FULLER.

THE most important work of the machine shop is the fitting of one piece to another. Sometimes there are exterior or isolated parts, to be finished and polished for appearance or for ease in cleaning; but such work forms but a small percentage of the total, and does not often have to be executed with any particular degree of accuracy. Perhaps no other word therefore is more frequently heard in the shop than the word "fit." What kind of a fit should it be? Do they fit properly? etc., are questions which always arise during construction and erection. Where there is a heated bearing, a loose crank pin, or a thumping in the engine, we hear, "What kind of a fit was that?" or "A poor fit." In many shops these fits are left to the judgment of a trusted workman or foreman, who, by experience in particular cases, has learned just what looseness or tightness is required. When new cases arise he applies his art and his judgment and solves them to the best of his ability. Consequently such workmen and foremen are invaluable to their employers, and are looked upon as experts, as indeed they are, meriting the admiration of all mechanics and engineers. Such men can sometimes impart to an exceptionally apt pupil a portion of this knowledge, but experience is after all the great teacher. The touch of the caliper and one's best judgment are difficult to impart to another. The growth of the machine business has been so rapid that there are not enough of these men to supply the demand. To-day individual machine shops are of such enormous size that an army of such men would be necessary for successful operation.



Arthur A. Fuller.

In general we have three kinds of fits; the running fit, the drive fit, and the force fit; but the fit between two pieces may vary greatly and still come under one of these kinds.

A running fit consists of such an amount of looseness between two pieces that one may move easily upon the other. In jewelled watch construction this amounts to .0002 inch, which seems to be sufficient to insure lubrication. In medium sized machine tool construction .001 to .003 inch seems to be about right. For main shafts and boxes of large steam engines, .01 or .02 inch may be necessary. In loom and agricultural machinery, some moving parts, though small, may require one-sixteenth or even one-eighth of an inch looseness. On rolling mill or mining machinery, one-eighth or one-half an inch looseness may be required for proper working. What then would one ordinarily understand by a running fit? Two persons who had worked together for many years might come to an approximate understanding of the nature of a running fit by the aid of such adjectives as loose, fair, average, good, snug, tight, etc.; but to a stranger, although accustomed to the same line of work, these expressions would have an entirely different meaning.

A drive fit consists of such an amount of tightness between two pieces, that it requires a succession of blows to make one move upon the other. For some classes of work the two pieces should be capable of being driven together by blows of a block of wood; other work should require the blows from a hammer or sledge; while occasionally the old style battering ram is brought into use for this purpose. An easy or light drive? A hammer or sledge drive? Yes; how heavy a hammer and how severe a blow? Here we are all at sea in regard to definite terms, and even a most explicit description of weight of hammer, length of handle, tension of muscle, method of swinging, etc., leaves one who has not witnessed the operation considerably in the dark.

A force fit consists of such an amount of tightness between two pieces that it will require some mechanical pressing or forcing apparatus to make one move upon the other. Some work requires that the two pieces be forced together by a lever or rack and pinion; other work by a screw jack or press, and yet other by the hydraulic press. When a lever or screw press is used, the amount of force is not readily measurable; but with the hydraulic press a pressure gauge may be used, which gives us in arithmetical terms the amount of force necessary. In fact this expression in pounds or tons pressure is the only case in which we can compare with any approximation to correctness the various degrees of force fits.

The subject of fits has caused many disputes and misunderstandings and surely more arguments than any other in the machine shop. The more minutely we try to describe a fit by adjectives the more deeply we find ourselves in the mire. Orders are placed and drawings made with directions, "free running fit," "easy running fit," "snug fit," etc., thus throwing the responsibility upon the judgment of the workman. He may succeed in making the fit satisfactory to himself, but will it satisfy the designer, the customer, his superintendent and his foreman? He may succeed in suiting one, occasionally two, seldom three, and perhaps once in a lifetime all four of them.

The inadequacy of language to express these varying degrees of fits has led to the adoption of definite amounts of looseness or tightness in many machine tool shops and other manufacturing establishments. But these amounts are often found to be arbitrary. "Somebody made it so once, it worked well enough, and we have made it so ever since." That is well, but you will find some one else making the same thing in another shop with about half the looseness or tightness you employ, and that works well enough also. This variation of practice led the writer, a few years ago, to make a few experiments on running fits to establish, for one shop at least, standard running fits for various sized pins and shafts. In determining these fits, it was deemed advisable to use the limit system, so that too much time should not be consumed in making practical fits. The tables and curves here given therefore express the maximum and minimum limits between which the required fit occurs. Whatever may be said against the limit system, it seems that here at least it is peculiarly adapted to serve a useful purpose.

The first step was to determine limits for holes. It is generally conceded that holes should be kept as near standard as possible, and to make a variation in the size of shafts or pins to produce the kind of fit desired. The limits for hole work were therefore compiled to bring every hole as near standard as practicable. The limits given for holes between 0.00 and 1.25 inches are perhaps narrower than have heretofore been attempted for a working shop standard, but the advent of the adjustable bladed reamer has made possible the production of accurate holes which the solid reamer can never hope to match. The limit is still exceedingly close, and designed to be used only on high grade work.

TABLE 1.—HOLE GAUGE SIZES.

Diameters.	Double Ended Plug Gauges.	
	Minimum.	Maximum.
.00 to 1.24	Diameter — .00025	Diameter + .00025
1.25 to 2.49	Diameter — .00025	Diameter + .00075
	Spherical Ended Reference Rods.	
	Minimum.	Maximum.
2.50 to 5.99	Diameter — .0005	Diameter + .001
6.00 to 11.99	Diameter — .001	Diameter + .001

employed was quite constant, being furnished by a nest of Bunsen burners. A second test was similarly conducted with pins with .001 inch clearance, and so on. The shafts, crank pins, and other moving parts, were lined up with considerable accuracy, a set of jigs aiding in accomplishing proper alignment. The test with the pins .0005 inch under size showed considerable power consumed in friction; the pins .001 inch under size gave better results, but still showed noticeable loss due to friction; the pins .0015 and .002 inch under size gave the best results, showing small loss from friction of pins and running quietly and smoothly. The pins .003 and .0035 inch under size were so noisy that they were black-balled. The bearing surface between links and pins was approximately one diameter long. The elements of friction in other parts of the engine were maintained constant as nearly as possible. These pins were being manufactured on a screw machine. It might appear from the test that the pins should be kept between .0015 and .002 inch under size, but these are scarcely practical limits for screw machine work, and as the pins .001 and .0025 inch under size gave good practical results, these were chosen as the maximum and minimum limits for sizes from .5 to 1.25 inches diameter.

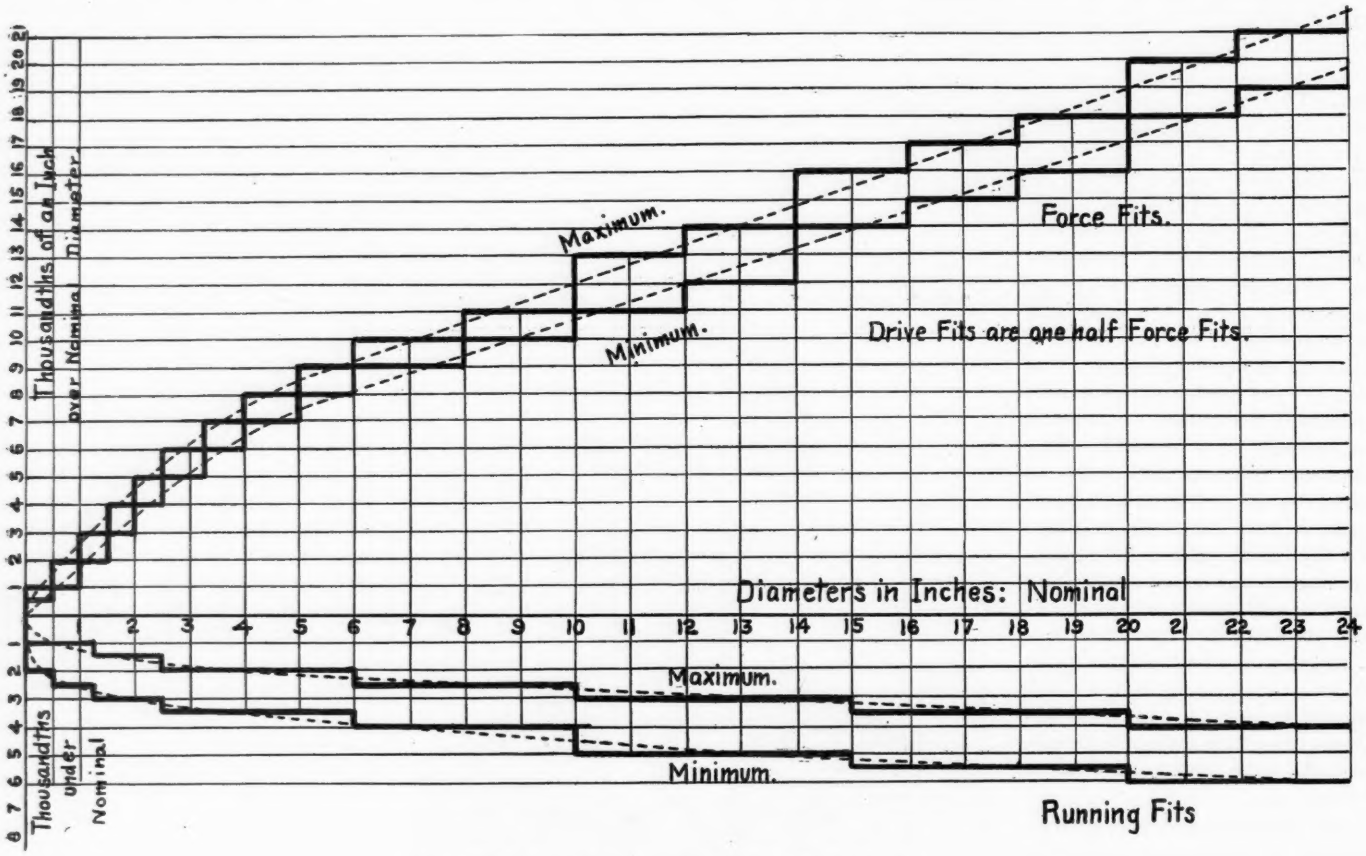


DIAGRAM OF SIZES FOR FORCE AND RUNNING FITS.

The tests for good running conditions for bearings below .5 inch diameter were made by observing the working of trains of accurately cut gearing mounted between two plates and driven by descending weights, similar in most respects to an ordinary clock movement, only larger. These trains were under manufacture as the driving mechanism for the registering instrument for the Venturi water meter. With the plates in proper alignment, repeated experiments showed that a clearance of .001 to .002 inch gave smoothest and easiest running. The shafts were six in number, with bearings ranging from 1/8 to 1/2 inch diameter and not greater than one diameter long. A favorable opportunity was at hand in the manufacture of the Ericsson & Rider hot air engines, which were being built by contract for the Delamater Iron Works, for a test with pins between 7/16 and 7/8 inch diameter. In the Ericsson engine are many solid-ended bronze connecting links, with holes in each end, running on steel pins varying in diameter as above. The holes in these bronze links were first reamed standard within ±.00025 inch. Sets of pins were then made .0005, .001, .0015, .002, .0025, .003 and .0035 inch under standard. A set of pins was then put into the engine, all with a .0005 inch clearance, and a test made by observing the quantity of water pumped against a given pressure. The heat

For pins 1.25 to 2.50 inches the Rider hot air engines gave opportunity for experiments similar to those with the Ericsson engine already described, and .0015 to .003 inch was decided upon for pins between these sizes. These three running fits were taken as the beginning of a curve to include all sizes of shafts and pins up to 30 inches diameter. Said curve is given above and the sizes are tabulated in Table 2.

The manufacture of Rice & Sargent steam engines of the Corliss type afforded a favorable opportunity to watch the working of the fits for larger sizes, and in most cases they have worked well. Much depends on accuracy of alignment. Babbitted pillow-blocks are sometimes made double running fit, but are often afterwards scraped to a bearing having even less clearance than a regular fit. Some may think these clearances too small, others too large, but the list of running fits thus established, whether or not chosen with the best of judgment, serves a useful purpose; it maintains a standard for the shop, which is applicable to nine cases in ten, and when a bearing is extra long or has particular service to do, directions can be easily and quickly given to double or halve the regular running fit. When this is doubled, the limits are of course doubled; when it is halved, the limits are halved, a change in the right direction in both cases.

TABLE 2.—SIZES OF RUNNING FIT GAUGES.

Diameters.	Single Ended Plug Gauges.	
	Minimum.	Maximum.
.00 to .49	Diameter — .002	Diameter — ,001
.50 to 1.24	Diameter — .0025	Diameter — .001
	Reference Discs.	
	Minimum.	Maximum.
1.25 to 2.49	Diameter — .003	Diameter —'.0015
	Spherical Ended Reference Rods.	
	Minimum.	Maximum.
2.50 to 5.99	Diameter — .0035	Diameter — .002
6.00 to 9.99	Diameter — .004	Diameter — .0025
10.00 to 14.99	Diameter — .005	Diameter — .003
15.00 to 19.99	Diameter — .0055	Diameter — .0035
20.00 to 24 99	Diameter — .006	Diameter — .004
25.00 to 29.99	Diameter — .0065	Diameter — .0045

The curve of force fits shown in the diagram and the list of force fits in Table 3 were compiled from the experience of every one who could be found to express an opinion, and from recent data obtained in steam engine practice from forcing cranks on shafts and crank pins into cranks by the hydraulic press. This list of force fits has been in use for several years with uniform success, and whether or not mathematically exact, furnishes as before a standard which has no uncertain sound. A good stiff drive is easily described as one-half and a light drive as one-quarter of the force fit. These two drive fits will take care of all the cases that arise in ordinary practice.

In drive fits for small pins, say from .50 to 2.00 inches diameter, much depends on the nature of the surfaces. With a turned pin one-half the force is generally necessary for a proper drive, while with a ground pin one quarter the force will be found adequate.

TABLE 3.—SIZES OF FORCE FIT GAUGES.

Diameters.	Single Ended Plug Gauges.	
	Minimum.	Maximum.
.00 to .49	Diameter + .0005	Diameter + .001
.50 to .99	Diameter + .001	Diameter + .002
1.00 to 1 24	Diameter + .002	Diameter + .003
	Reference Discs.	
	Minimum.	Maximum.
1.25 to 1.49	Diameter + .002	Diameter + .003
1.50 to 1.99	Diameter + .003	Diameter + .004
2.00 to 2.49	Diameter + .004	Diameter + .005
	Spherical Ended Reference Rods.	
	Minimum.	Maximum.
2.50 to 3.24	Diameter + .005	Diameter + .006
3.25 to 3.99	Diameter + .006	Diameter + .007
4.00 to 4.99	Diameter + .007	Diameter + .008
5.00 to 5.99	Diameter + .008	Diameter + .009
6.00 to 7.99	Diameter + .009	Diameter + .010
8.00 to 9.99	Diameter + .010	Diameter + .011
10.00 to 11.99	Diameter + .011	Diameter + .013
12.00 to 13.99	Diameter + .012	Diameter + .014
14.00 to 15.99	Diameter + .014	Diameter + .016
16.00 to 17.99	Diameter + .015	Diameter + .017
18.00 to 19.99	Diameter + .016	Diameter + .018
20.00 to 21.99	Diameter + .018	Diameter + .020
22.00 to 23.99	Diameter + .019	Diameter + .021
24.00 to 25.99	Diameter + .020	Diameter + .022
26.00 to 27.99	Diameter + .022	Diameter + .024
28.00 to 29.99	Diameter + .023	Diameter + .025
30.00 to 31.99	Diameter + .024	Diameter + .026

Having determined upon the fits and established the limits therefor, the next important matter was to furnish suitable gauges for the workmen. The hole gauges from 0.0 to 2.5 inches form a particularly fine set of double-ended plug gauges, made especially for this use by the Brown & Sharpe Mfg. Co. The small end of the gauge which should "go in" and thus receives the most wear, is made longer, and is thus easily distinguished from the large end without looking at the sizes stamped upon the gauge.

For the running, force and drive fits between 0.00 and 1.25 inches single ended plug gauges are employed. They are of the usual form as shown in Fig. 1, but the length of the ground portion is longer or shorter by one-sixteenth of an inch for every .001 inch it is above or below the standard size, so that any two gauges which might be chosen to constitute the limit for a piece of work in the neighborhood of .75 inch would show by their length which was maximum and which minimum.

For the running, force, and drive fits between 1.25 and 2.50 inches reference discs are employed, the width of the disc being as above an index of its relation to standard size.

These single ended plug gauges and the reference discs are designed to be used as sizes only for turned work, the size being transferred by means of calipers from the gauge to the work. For this purpose two pairs of ordinary spring calipers are given out to be set and used as maximum and minimum gauges by the workman. The workman may use as strong or delicate a touch as he may desire, but uses the same touch on his work. This method is surer and quicker than snap gauges and does not cost as much for maintenance, as the sizer is practically indestructible. These plug gauges and reference discs are all kept in a revolving cupboard, one view of which is shown in Fig 2, page 70.

Above 2.5 inches the plug gauges and reference discs become rather heavy and bulky, so that for all gauges here listed above that size the spherical ended reference rod was adopted. The ends of these rods are so ground as to form a portion of the surface of a sphere whose diameter is equal to the length of the rod. This gives a line contact between gauge and work when used in a cylindrical hole of same diameter, thus insuring great durability. This form of rod also refuses to become cramped in a hole. It can be inserted at random, and revolved after it comes in contact with the work, when the work has reached correct diameter. The form of rod shown in the photograph is the result of some experience. It is bevelled off on two sides, at each end, so that the workman may try for the size of his hole after he has run his cut $\frac{1}{16}$ inch into the work. If this were not done he would have to run about $\frac{3}{16}$ inch deep before he could

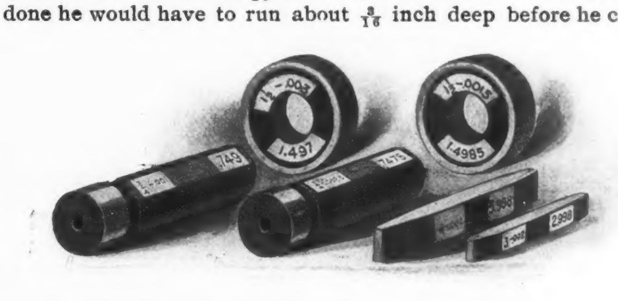


FIG. 1.—REFERENCE DISCS, PLUG GAUGES AND REFERENCE RODS.

try for his size. They are made of square stock, to prevent their rolling about when laid on bench or table of the machine. For exterior work they are used as sizers, to which the ordinary calipers are set. The narrowing of the end of the rod in one direction and its small curvature in the other direction, makes it exceedingly easy to find the "high point" on the rod.

In Fig. 3 is a view of a portion of the rack used for holding the rods, which shows the construction in detail. The partitions are small pieces of sheet iron inserted between the shelves, and there is a groove along each shelf near its front edge, to prevent the check from rolling into the back end of the pigeon hole.

The Brown & Sharpe Mfg. Co. list in their catalogues spherical ended rods made of round steel without bevelled ends. The idea is probably not new, but the thought occurred independently to Mr. F. N. Connet, of the Builders' Iron Foundry, several years ago. He designed an apparatus, which was promptly made in the foundry, for making the spherical ends accurately. The rods were further developed and a large number made and used several years before the Brown & Sharpe Mfg. Co. completed their machine for the same purpose.

It has been argued that in case of the force and running fits the length of bearing should appear as a factor in determining the amount of tightness or looseness between two pieces. For the force fits the arguments have little weight. Take the fly-wheel of an engine, for example; if the hub is designed longer it is because the fly-wheel has extra weight and is expected to do extra work, and it is only reasonable to suppose that it should take extra pressure to force it on to the shaft. With a given force fit the metal of the hub is not strained any more for a long hub than for a short one. It is said that the English use many wheels without keys, depending only upon the force fits. Perhaps if we should always maintain a suitable standard force fit, desgin our hubs long enough and provide ourselves with suitable forcing presses, we could follow in their foot-steps and be rid of the fly-wheel key forever.

In case of the running fit the length of bearing seems to have little to do with proper looseness. When bearings and shafts are cylindrical and in line, and are properly designed to withstand the pressure required of them, it is only necessary to have an amount of looseness sufficient to allow a suitable film of oil to remain between shaft and bearing. The length of the bearing seems to make little difference when proper oil-grooves are pro-

vided to conduct the oil longitudinally along the shafts. It will be noted that the curve of running fits near the zero point departs rapidly from the axis representing standard size, but soon changes direction and runs almost parallel thereto.

It may be said that the establishment of such standards is but the accumulation of shop experience in writing, but shop and engineering experience thus crystallized and given to the draughting office and foremen in proper form is of great value. It enables them to determine quickly, upon paper in one case and in directions to the workman in the other, what kind of a fit to

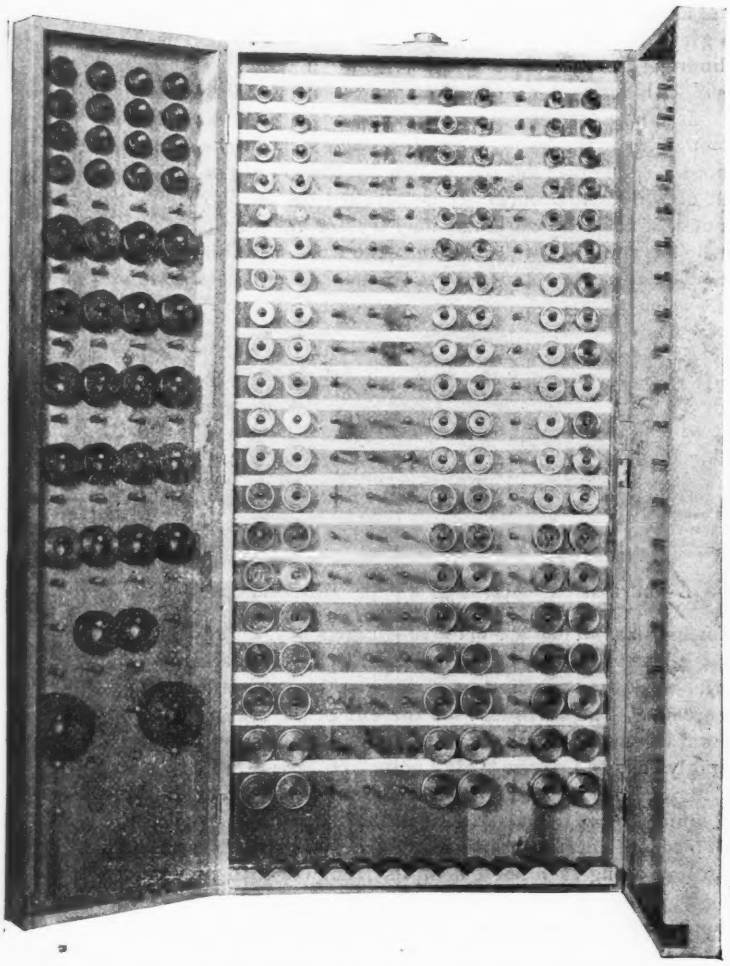


FIG. 2.—REVOLVING CUPBOARD—REFERENCE DISC SIDE. (SEE PAGE 69.)

specify. For duplicate and interchangeable work where gauges are absolutely necessary, the system has the advantage of cheapness and convenience, and prevents errors due to mistakes in reading verniers and micrometers. The workman who has neither of these instruments can obtain the two exact sizes, between which his work must be made, on check at the tool room. With the aid of the reference rod it allows us to go into sizes far outside the scope of ordinary micrometers. For a shop with several departments doing a variety of work, it prevents the accumulation of an unnecessary number of duplicate gauges, or gauges so near the same size that one might answer for both, and thus harmonizes the work of various departments.

* * *

IT MEANS CONSIDERABLE.

The Industrial Press, New York, N. Y.:

GENTLEMEN: You will no doubt be interested in hearing the following from our Mr. Davis, who is now traveling through the various countries of Europe. "I see MACHINERY everywhere I go."

The above is short but it means considerable, and we hope that you will continue to spread yourselves in the European territory, as it is certainly the only field from which the American machine tool builders are drawing any great amount of trade at the present time.

Yours very truly,

THE DAVIS & EGAN MACHINE TOOL CO.
B. B. QUILLEN, Sec. and Gen. Mgr.

KELLY'S DIRECTORY.

The agents of Messrs. Kelly & Co., Ltd., of London, Eng., are canvassing the machinery trade in this country for subscriptions to their directory of merchants, manufacturers, etc., which is supposed to include all such firms in the world, but if we are to judge their foreign lists by the one they publish of the machine trade in this country, they must be very far from complete.

We note among other similar addresses in their classified list of bicycle manufacturers in this country: Monarch Cycle Co., 83 Reade street, New York; Pope Mfg. Co., 12 Warren street, New York; Overman Wheel Co., 23 Warren street, New York; all useless addresses for any manufacturer desiring to sell these concerns machinery or to reach them with advertising matter.

We find no machine shops whatever given in Rochester, N. Y., Fitchburg, Mass., and other cities of like importance, while in Providence, R. I., the sole name appearing under the heading "Manufacturing Machinist," is Chas. H. Field, and the following list of sewing machine manufacturers is given as located in that city: Brown & Sharpe Mfg. Co., Davis Co., Domestic Sewing Machine Co., Household Sewing Machine Co., MacLeod Mfg. Co., Edward Parkinson, Singer Sewing Machine Co., Tillinghast Sewing Machine Co., Wheeler & Wilson Mfg. Co., White Sewing Machine Co., Wilcox & Gibbs Sewing Machine Co.

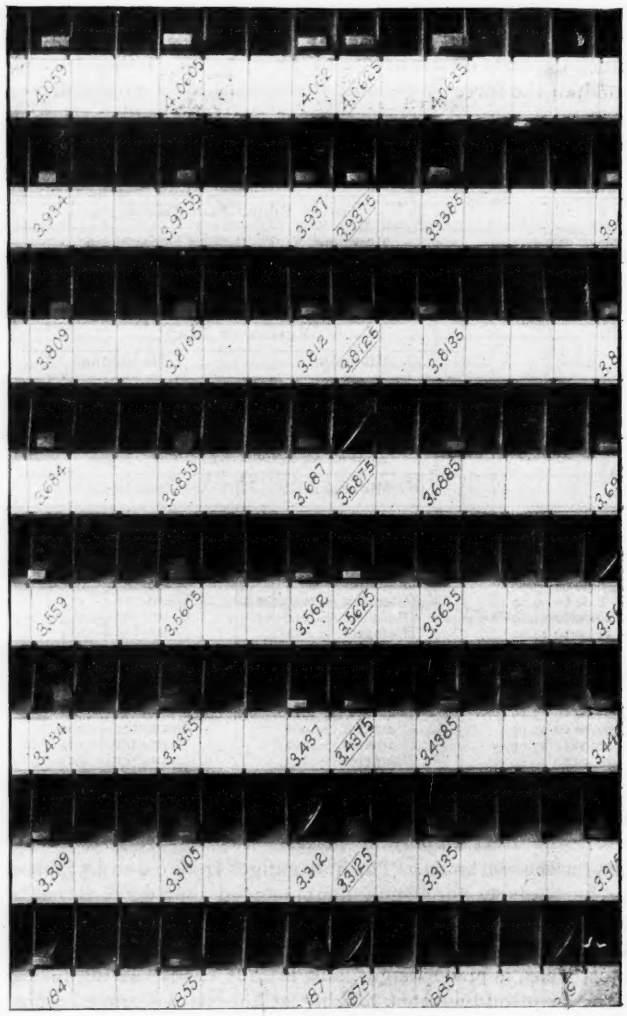


FIG. 3.—DETAIL OF RACK FOR RODS. (SEE PAGE 69.)

Messrs. Kelly & Co. is a reputable concern, publishing, we believe, the directory of the City of London, and other well known works of merit and standing; but they have been outrageously imposed upon by those in charge of the work of compiling a directory of the machinery trade of the United States.

Our acquaintance with that trade is naturally much better in the United States than in foreign countries; but we find a number of the principal machinery dealers in Russia omitted from the book, and our own list of the trade in that country, which is far from complete, includes more than five times the number of names in Kelly's Directory.

BRASS WORKING TOOLS.—4.

FRED H. COLVIN.

The subject of boring bars would be hardly complete without a reference to "inside" boring tools, or tools for counter-boring on the inside of the work.

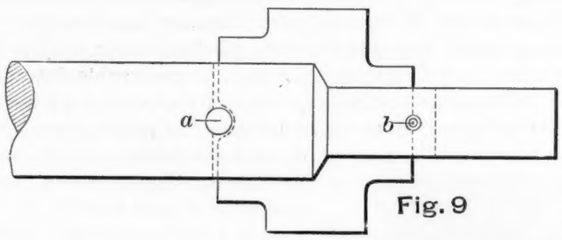


Fig. 9

Fig. 10 shows an injector body (Rue Little Giant) in which the combining or middle tube is packed at each end by external ring packing. This requires counter-boring and tapping for the packing nuts, after the first or main hole is bored. A little ingenuity is required to do this, but it is an old story with tool makers on this kind of work. Fig. 9 shows the arrangement.

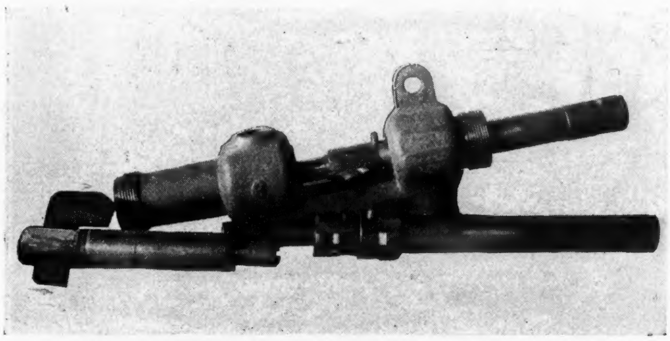


FIG. 10.

A bar is made of the right size for the main hole (there are two sizes on this bar), as the steam end of the combining tube is larger than the other end. The bar is mortised as for any cutter and the pin *a* is driven solid into the bar to center the cutter on the back end, although any other device can be used for this purpose.

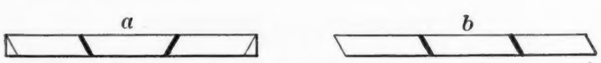


Fig. 11

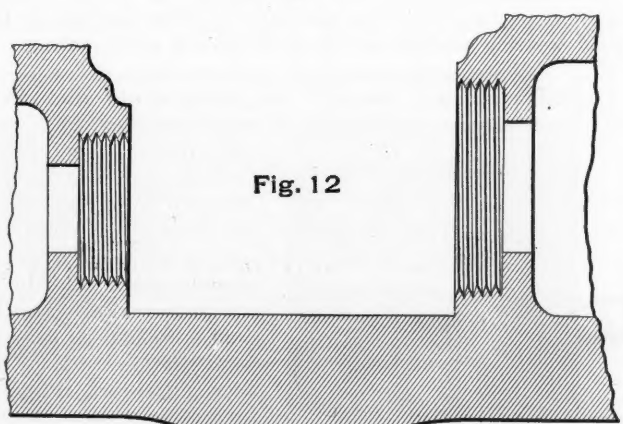


Fig. 12

The pin *b* is removable, and has rounded ends for convenience. To use this style of bar, remove the cutter, push the bar through the injector body (or any other similar work) till the mortise is clear. Insert the cutter, put in pin *b* tightly and pull the work round by hand for one turn to see that all is clear, and then start the lathe running and go ahead.

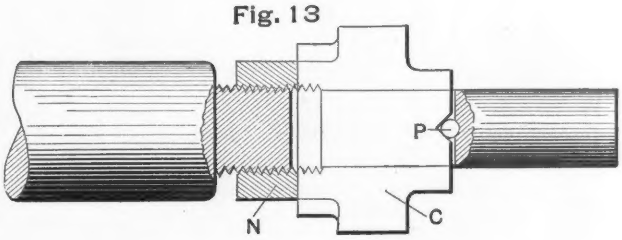
By grinding the cutter as shown in *a*, Fig. 11, the lathe need not be reversed for either end. Some make the mistake of grinding it like *b*, which necessitates reversing the lathe after counter-boring one end. After boring, the cutter is removed and the bar withdrawn.

Then the tapping bar is inserted, the taps being slid over the end before it is shoved clear into place, and the taps pinned in place. The taps are cut and milled like any tap—to cut right-handed in this case, and they are used somewhat differently from the cutters in this respect.

Starting the lathe forward runs the front tap into the work. Reversing the lathe brings it out, and with the lathe still running backwards the back tap is run into the work on its end. If this seems puzzling, think it over a minute and it will be clear to you. This saves reversing the lathe before starting the second tap in, and in fact it couldn't be worked any other way (with both taps either right or left-handed) if you wanted to do so. Fig. 10 also shows a boring bar with an outside or "wing" milling cutter attached or rather put through the bar. In order to make the essential features of this bar perfectly plain, the sketch, Fig. 12 has been made, which shows clearly the counter-boring and tapping of larger diameter than the main hole.

Still another style of inserted cutter bar for this class of work is shown in Fig. 13, which is more elaborate and expensive than the pinned cutter, but which does no better work. Still some may prefer it.

Fig. 13



The bar is slotted as usual and the permanent pin P inserted to center it. The back end of bar is threaded and the nut N screwed on. When the nut is back against the shoulder, there is room for the cutter to be inserted. When screwed against the flat face of the cutter *c*, it forces it against the centering pin and holds it firmly during its work. It has the disadvantage of affording the fiend who throws all his weight on the monkey-wrench every time he uses it, a good opportunity to split the cutter or do other damage.

In closing, it may not be out of place to say that the writer has found it advisable to draw the temper on brass working tools below that used on other machine work. Generally speaking, a temper which mixes the blue and the straw colors will not be as apt to break, and will not require too frequent grinding.

* * *

CORRESPONDENCE SCHOOL INVESTIGATION.

Through arrangements which have been completed by the publishers of *Electricity*, a committee consisting of three men is to investigate the system of correspondence instruction as carried on by the International Correspondence Schools, Scranton, Pa., the Correspondence School of Technology, Cleveland, O., and the Institute for Home Study, of Cleveland. The investigation is being undertaken, not because of any suspicion attached to these schools, but because it is thought that a report, coming from an impartial committee, if favorable, would place them in a higher position in the confidence of the public than they have ever occupied. While this may redound to the benefit of the schools themselves, it is thought that a larger benefit will accrue to those who hitherto have not availed themselves of the opportunities offered because of the lack of any competent and disinterested indorsement of such a course.

In their endeavors to assist the committee, the two Cleveland schools have offered to provide free scholarships to a certain number of young men to be appointed by the committee, with the idea of affording the latter a better opportunity for observing results and incidentally (presumably) to advertise the schools. While this will be a good thing for the appointees and will probably help along some worthy young men, we fail to see wherein it will help the committee to arrive at any just conclusions. The only way that such conclusions can be reached is by investigating the results that have been obtained with average students who have received no special attention, such as these picked men would inevitably receive, even with the best of intentions on the part of the instructors.

NOTES FROM THE FITCHBURG MACHINE WORKS.

LATHE BUILDING, LARGE AND SMALL—AN EXERCISE FOR APPRENTICES—INSPECTING TOOLS—ROTARY FANS.

The Fitchburg Machine Works, Fitchburg, Mass., had its beginning in 1864, when a small shop was started by S. C. Wright & Co., the members of the firm being S. C. Wright and J. L. Chapman. In 1867 they moved to quarters in the buildings now occupied, and at the present writing have a floor space of over 40 000 square feet. Soon after their removal to these works a stock company was formed under the style of the Fitchburg Machine Co., of which S. C. Wright was president and J. L. Chapman treasurer. In 1879 the stock company was dissolved and the Fitchburg Machine Works was formed, of which J. L. Chapman is treasurer and manager. Ever since the formation of the original company, the aim has been to manufacture a complete line of machine tools, including all or nearly all of the standard machines required for the equipment of an ordinary shop, milling machines excepted. A large stock is now carried of completed machines and of parts ready to be assembled.

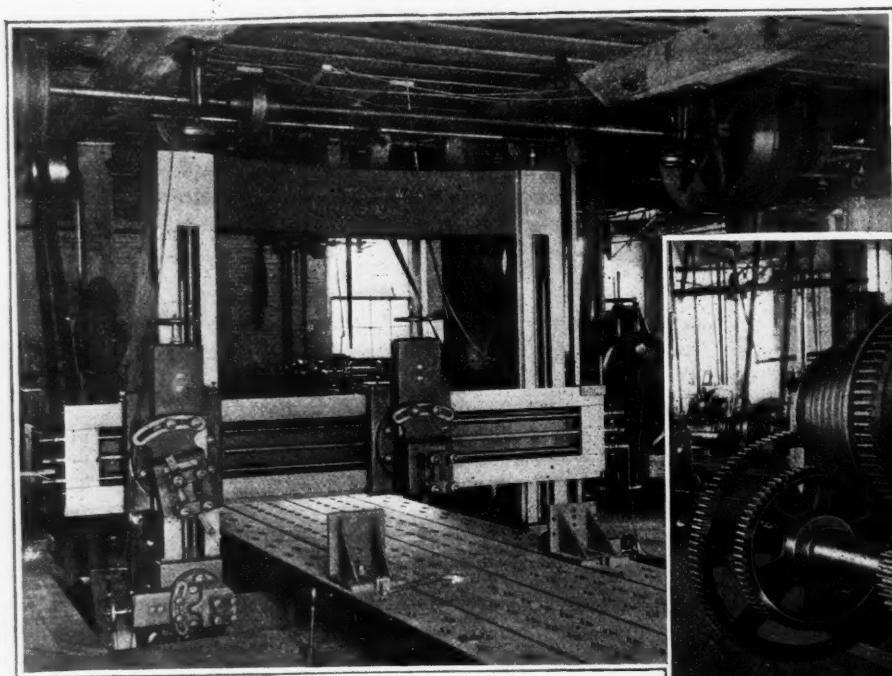


FIG. 1.—72-INCH PLANER.

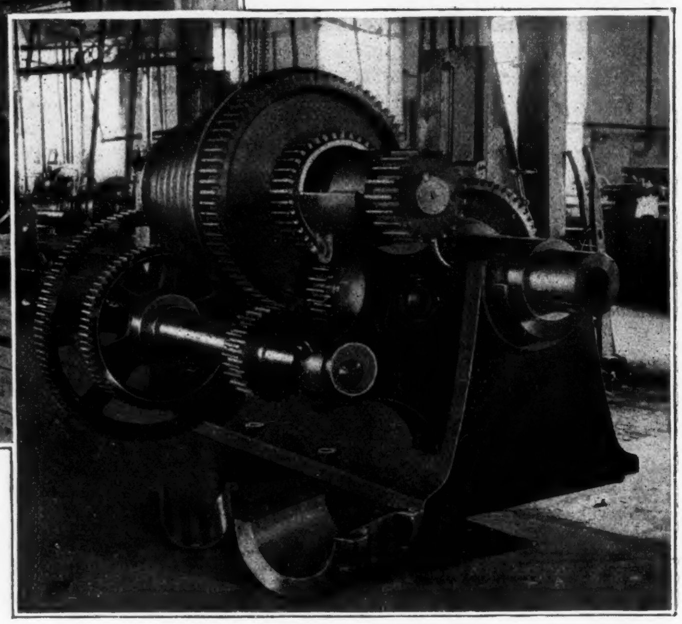


FIG. 2.—60-INCH HEAD-STOCK.

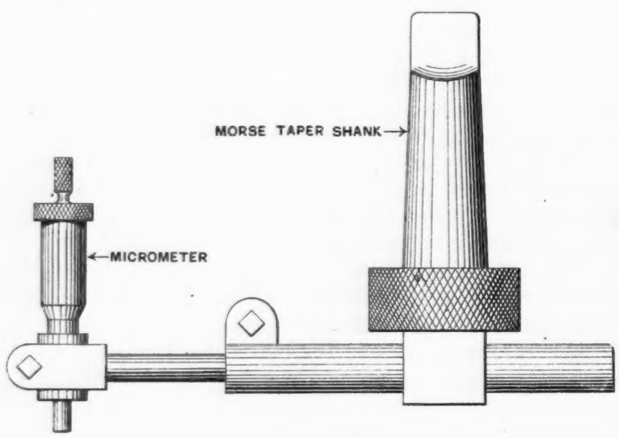


FIG. 3.

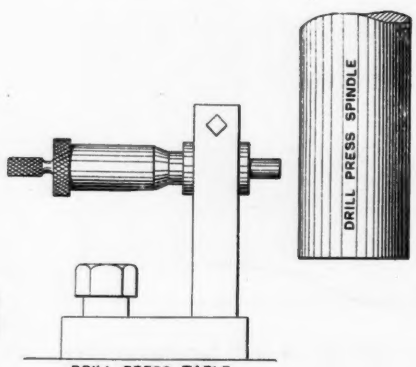


FIG. 4.

During a call at these shops I was shown a very complete set of jigs, which had been made for the manufacture of the new 14-inch "Gem" lathe, with which our readers are already familiar. The designer of this lathe had evidently made a careful study of the requirements necessary for its economical manufacture and of conveniences, which, while not so necessary on a larger machine, are always appreciated on one of this size. There are many of these points about the lathe that one would notice who is accustomed to the regular Fitchburg pattern. Among the jigs was one for boring the main bearings of the head-stock, which was to be used after the head-stock had been planed. This order of operations is coming to be more generally adopted than the older method of boring first, driving in an arbor, setting up on Vs and planing, and ought to give better and more uniform results.

There is very little in the way of special machinery to be seen at these works, dependence being placed, rather, on jigs and fixtures, for use on regular machines. A noticeable feature, however, is the large number of their own tools which go to make up their equipment, from the smallest to the largest sizes. By way of contrast to the 14-inch lathe just mentioned, Figs. 1 and 2 show good examples of their heavier work. The first is a 72-inch planer, situated at one end of the planer department, and the second a head-stock for a 60-inch lathe, which was in progress of construction at the time. This head-stock has main bearings 10 x 15 and 7½ x 10 inches, with bronze boxes having strips of babbit inserted, giving spindle bearings of alternate strips of bronze and babbitt, which are said to have good wearing qualities and do not trouble at all by cutting.

A PROBLEM FOR APPRENTICES.

As the face-plate is removed, the gearing on the head-stock is very clearly shown and it would be a good problem for a young mechanic to follow through with it if he has never attempted to do so on one of these large lathes. He should make an outline sketch, which will help him to plan the arrangement, and on which he can indicate the direction of rotation of the gears. Reterring to the figure, it will be seen that the cone and back gears are placed in front of the main spindle. The latter is driven from the cone spindle through an intermediate gear, which is just visible back of the front end of the head-stock casting. This gear gives the cone and the main spindle the same direction of rotation. There are double back gears, which, together with the five steps on the cone give 15 changes of speed when driving through the main spindle. The lathe is also triple-geared and is driven through the steel pinion seen in front on the end of the cone spindle, which runs in an internal gear on the face plate. This gives 15 speeds when gearing into the face plate. Provision

must be made, of course, for moving the steel triple-gear pinion out of gear, where it is intended to drive through the main spindle, and also for throwing in either of the back gears, as desired, and only one at a time. With these hints any apprentice should be able to study out the problem.

INSPECTING MACHINE TOOLS.

In the inspection of the finished machines, a special form of micrometer is used instead of the more common test indicator. This micrometer, with the special devices for using it, make an interesting collection of instruments for fine measurement.

In Fig. 3 the micrometer screw is clamped at the end of an adjustable arm attached to

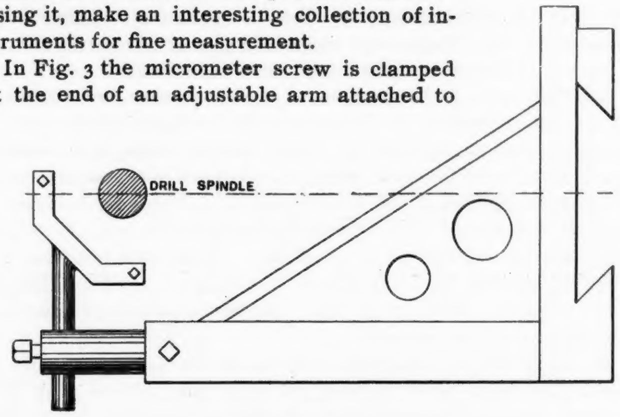


FIG. 5.

the lower end of a taper shank holder, designed to fit the taper socket of a drill press spindle. The device is used for testing drill press tables and determining the amount that they are out of square with the spindles, if any.

In Fig. 4 is a small knee which holds the micrometer screw and is clamped to the drill press table; it is used for determining whether the spindle runs out, and if so, how much.

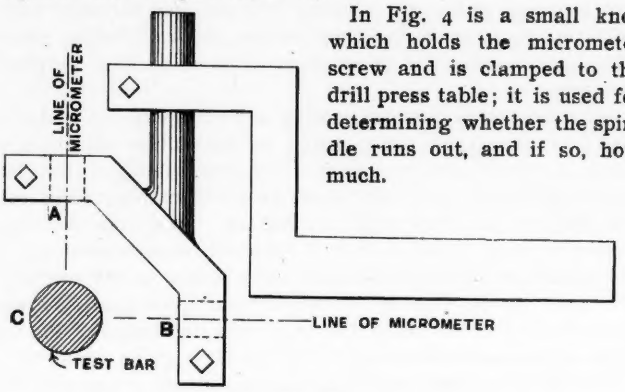


FIG. 6.

Another device for testing the alignment of drill press spindles is shown in Fig. 5. It consists of a knee which is designed to clamp on the slide on the upright. At its outer end is a double

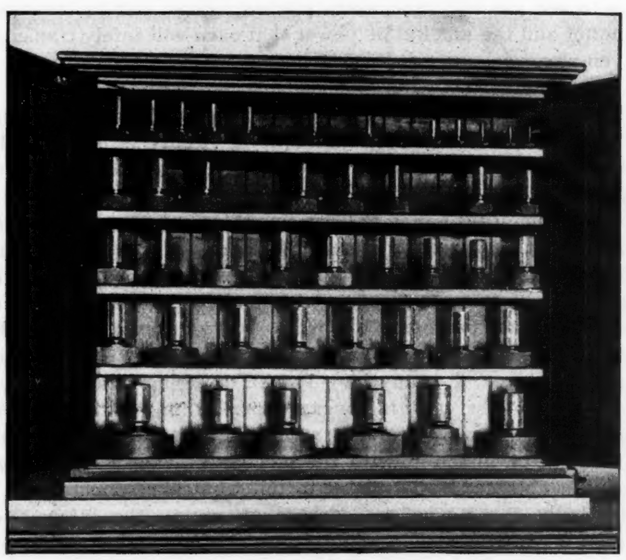


FIG. 7.—CUPBOARD OF HOME-MADE GAUGES.

holder for supporting the micrometer screw in either of two positions at right angles to each other; and adjustment is provided for, so that the micrometer can be brought in line with the spindle. This device is used in testing the alignment of the spindle with the slide. For use with a test-bar in an engine lathe this same double holder is supported by a bent piece, similar to that illustrated in the sketch in Fig. 6, which can be clamped in the tool post in place of the tool.

However thorough a system of inspection may be, it cannot amount to much unless there are standards to work to. I was glad, therefore, to be able to photograph a cupboard of standard plug and external cylindrical gauges (Fig. 7), ranging from ¼ inch to 5¼ inches in diameter, which were home made and which, after completion, were inspected by the Brown & Sharpe Mfg. Co. They appeared to be a very creditable piece of work, especially for a concern which does not pretend to be in the gauge business.

A FEW KINKS—ROTARY FANS.

In Fig. 8 is a photograph of a cone pulley turning fixture, together with the dog used for driving the pulley. The fixture is arranged to bolt on to an ordinary lathe carriage, in place of the

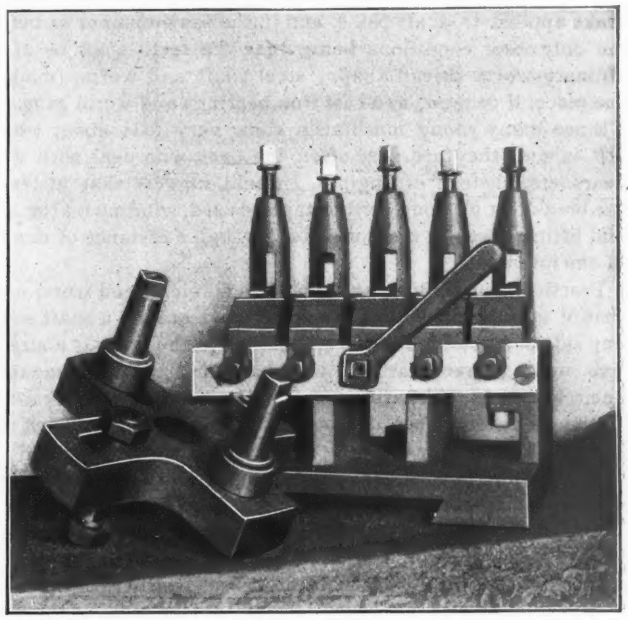


FIG. 8.—CONE PULLEY TURNING FIXTURE.

ordinary tool block, and needs no description. With a powerful drive and suitable provision for crowning the pulley, such as might be made with a lathe having a taper attachment, or better still, with a lathe like the Fitchburg gauge lathe shown in our September issue, it ought to do rapid work.

Somewhat of a novelty in the screw-driver line is shown in Fig. 9. Sets of these, comprising several sizes, are distributed about the works. The screw-driver body is of machine steel, slotted at the end to hold a square, tool-steel plate of the right thickness for screws that the screw-driver is likely to be used upon. This plate gives four wearing edges, and will probably

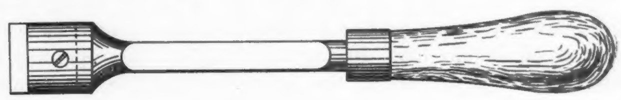


FIG. 9.

last as long as the rest of the tool, but should it break, a new plate can be quickly inserted.

Rotary fans are rather of a breezy subject for November, but it is one that will bear keeping in mind until the warm days of next summer. Not only the offices, but the draughting-room and the foremen's desk are equipped with these fans at the Fitchburg Works. Like the gauges, they are of home manufacture, and appear to be of much better workmanship than the ordinary commercial article.

I have often wondered why a manufacturer should supply his office with fans and omit the draughting-room. The draughting-room is generally at the top of the building, where it is at the mercy of the sun, and draughting has enough manual labor connected with it to make a man want to take off his coat and roll up his sleeves, even on a moderately cool day. On a hot day everything gets sticky and dirty, the flies bother, and work lags. It is a pleasure to find a firm which takes this into account.

L. G. F.

SOMETHING TO THINK ABOUT.

A CORRESPONDENT WANTS TO HAVE THE SUBJECT OF WORM GEARING DISCUSSED—A PLEA FOR PLAIN LANGUAGE.

Mr. Editor:—There is one subject that I have not seen discussed in your columns, and it is one that I am sure would be decidedly interesting to many others as well as myself. I refer to worm and spiral gearing in regard to the size, pitch, etc., to obtain the greatest efficiency from a given power.

Take, for example, a small engine with the size and speed of fly-wheel given, and belted to a shaft with a brake attached showing that exactly one HP. is being obtained from the shaft. We will call this shaft No. 1, and allow the pulley on it to be changed to any size desired.

The problem shall be to place another shaft (No. 2) at right angles to shaft No. 1 and drive it by a worm and worm gear that will give the greatest efficiency as indicated by the same brake applied to shaft No. 2, and in the same manner as before; the only other conditions being that the teeth shall be of the ordinary worm thread shape; steel shaft and worm, (made in one piece, if desired) and cast iron bearings and worm gear.

Since many young machinists know very little about what a HP. is, and they are very often the ones who deal with worm gears, etc., instead of engines, I would suggest that instead of the break test a strong cord or tape be used, winding on the shaft and lifting a weight of 33,000 lbs. through a distance of one foot in one minute.

Practically speaking, the action of a single thread worm is like that of a wedge; the wedge being wound around a shaft so that one side of the wedge forms a helix, while the other is a straight line running directly around the shaft and just long enough to encircle it. As the shaft is revolved the wedge travels by a tooth in the gear and pushes it around a certain amount at each revolution of the shaft.

Considering the thread as a straight wedge, the power that drives it may be considered as applied by a lever having a fulcrum at the center of the worm and delivering its power to the wedge at the pitch line of the worm, the stationary support for the wedge taking the place of the thrust bearing for the worm

The thickness of the wedge is equal to the pitch of the worm and when it has performed its full amount of work upon one tooth of the worm gear it has pushed the gear around just far enough so that the next tooth is in position to be operated upon during the next revolution of the shaft, and so on around the gear, one revolution ot the shaft (or worm) for each tooth in the gear.

Since the length of the wedge is just sufficient to encircle the shaft and no more, and the thickness of the wedge depends upon the pitch of the worm, it is evident that the taper of the wedge can be increased or diminished without changing its thickness by simply varying the diameter of the shaft; but when the diameter of the shaft is changed, the distance from its center to the wedge is changed also; which corresponds to the distance from the fulcrum of the lever to the wedge.

Imagine that the point of a wedge is placed in the crack between two heavy blocks on a smooth surface and struck with a blow equal to 100 lbs., driving it 10 inches and opening the crack one inch by forcing the lighter of the two blocks away from the other. If the wedge is withdrawn and the blocks placed close together again, and the point of a wedge 100 inches long and one inch thick placed between them, a succession of 10 lb. blows would probably open the crack one inch, also. In the same way, by increasing the diameter of the shaft, the length of the wedge can be increased without changing its thickness and a smaller amount of force will move it, because its taper per inch is less, but to move it far enough to turn the worm gear as much as the entire thickness of the short wedge (one inch) and in the same length of time, it is necessary to move it further in the same length of time; that is, a greater length of surface must pass by the tooth in the same length of time, while the length of the lever from fulcrum to wedge has been increased also, lessening the amount of power that can be obtained from it with the length of its other end and the power applied remaining the same. In the language of our country cousins, we might say that we have got a "longer bite with the same fry," a lighter load and further to lift it. In short, if the diameter of a worm is doubled, the amount of wearing surface and its distance from the center is doubled also, while the helical angle (taper of the wedge) is lessened. Now, then, from what diameter will the greatest efficiency be obtained from a worm of given pitch? Does the power derived from lessening the helical angle compensate for the loss of power due to the increased leverage and amount of wearing surface?

By doubling the pitch without enlarging either the worm or worm gear, only one-half the number of revolutions of the worm are required to impart a given number of turns to the gear, but it takes more power to turn the worm, owing to the *increase of the helical angle*, which is like using a short thick wedge. What pitch and what size of worm will give the best results? (In referring to diameters, pitch diameters are meant).

Another item to be considered is the diameter of the worm gear. By increasing its diameter without changing the pitch or size of worm, the number of turns that the worm must make to one revolution of the gear must be increased in proportion, while the power required at the circumference of the gear to turn it is less, on account of the increased leverage, which is like using a long wrench instead of a short one. This also increases the wearing surface that must come in contact every time the gear turns around. How would this change in wearing surface and leverage affect the efficiency?

By using the same number of teeth on the worm gear, and the same size worm with *coarser pitch* the size of the gear is increased, while the number of revolutions that the worm must make remains the same, but the helical angle and wearing surface is increased, which would make the worm turn harder against the same resistance, while the gear turns easier. This same result can be obtained by using a worm with double or triple thread, and if we go far enough in this direction we get spiral gears which are nothing but multiple threaded worms, although the men in the shop seldom think of helical gears in this light. Thus the question of pitch is another perplexing problem.

Friction losses in worm gearing are a large factor, and it cannot be expected that the 33,000 lb. weight will be raised one foot high in one minute by shaft No. 2, mentioned above; but, What pitch and size of worm and worm gear will enable it to be raised the highest and how high will that be? Of course, the relative speed required, the diameter of the shaft on which a worm must be placed, etc., frequently leave little choice in the matter, but from the results that are obtained from spiral gearing it would seem that if all the items that enter into the design of the worm and worm gear called for by the problem given could be computed and the right combination determined, it would be found that in actual practice the worm is in most cases larger in proportion to the pitch than it should be to obtain the greatest efficiency, (durability not considered).

When these questions have been decided and the maximum efficiency that can be obtained from shaft No. 2 found, I would like to see the different worm pitches figured out in the same manner and the amount of power that each will safely transmit, given also.

Right here I will add a plea for plain language by saying that I do not believe that one mechanic in twenty is benefited by nine-tenths of the matter written for his instruction, simply because it is beyond his comprehension.

It is difficult for a man to learn two things at once although he might be able to master either one alone, and when he is trying to obtain information on mechanics he wants it explained in the language he is most familiar with, and in the plainest possible manner, instead of being obliged to study up a lot of algebraic formulas, etc., that he can hardly remember even if he ever understood them. It is anything but encouraging to an ambitious young machinist, studying over a paper for information on some point, when there is so much "stuff," the meaning of which he is uncertain of, mixed up with the mechanics, that when a wrong result is obtained he is unable to tell what is responsible for it. No doubt those who are capable of giving the information asked for in this article would be capable of understanding the most difficult mathematics that I could submit, but I do not want to give them the chance to call me down for not practicing what I preach; besides I hope that anything that may be called out by the foregoing will be better understood by those who have requested me to bring the subject up, by putting it to your readers as it has been put to me.

A. L. G.

PRACTICAL PATTERN MAKING.—6.

PATTERN WORK FOR SCREW PROPELLERS WHEN SWEPT UP IN LOAM.

I. McKim Chase.

One of the most interesting objects swept up in loam and which to be successful requires considerable skill and experience on the part of the pattern maker and molder, is a large screw propeller cast entire.

Figs. 52 to 58 inclusive show the preparations necessary to be made by the pattern maker when the mold of a large screw propeller is intended to be swept up in loam.

Fig. 52 represents the guide, or directrix, upon which the blade face, sweep, or generatrix, travels to produce the helicoidal surface. The guide is usually set six inches beyond the periphery of the blade, to allow for the joint of the mold.

At one time guides were made of plate iron cut to the proper angle and secured to a base of wood after being bent to the required curvature. The term "guide iron" was derived from this method of making them. A guide made entirely of wood is, however, preferable.

Fig. 53 illustrates how the curvature of the guide may be obtained. An arc of a circle of the radius of the position of guide from the axis is described for the base. The degrees of the arc should be somewhat greater than the angle occupied by the blade when it is viewed parallel with the axis, in order to allow for a joint at both the top and bottom edges of the blades. The arc is divided into any number of equal parts, as *a*, *b* and *c*. The length of the inclined rail is obtained by laying down its angle with one end intersecting one extremity of the base line, and the other end intersecting a perpendicular from the other extremity of the base. The length of the rail is divided into the same number of equal parts as the base and ordinates of like letters made equal in length. A curve drawn through the extremities of the ordinates will be the elliptic arc, to which the rail is to be worked. In constructing the guide, the rail is left sufficiently wide to allow for finishing the top edge, which is the last work done on it. To lay off the guide a line is described parallel with the base and about four inches from the bottom, which is to allow for a joint in the mold. The length of this line, or arc, will be that intersecting radial lines which are tangent to the edges of the blade when it is viewed parallel with the axis. The arc is divided into equal parts, and it is advisable to have one of the intersections in the center, to be used as a center line. Perpendiculars are erected from the intersections, and the length of the ordinates for the angle of the guide laid off on them. A thin strip, or batten, is then tacked on the inside of the rail, intersecting the extremities of these ordinates. A line drawn along the top of the batten on the rail will be the guide line. The rail is to be worked off to this line, a try square, with the stock held vertically, being used to gauge the shape of the edge.

For a screw of uniform pitch, the guide line developed on a plane is a straight line. For a screw of expanding or increasing pitch, the line developed is a curve, the ordinates for which should always be given on the drawing.

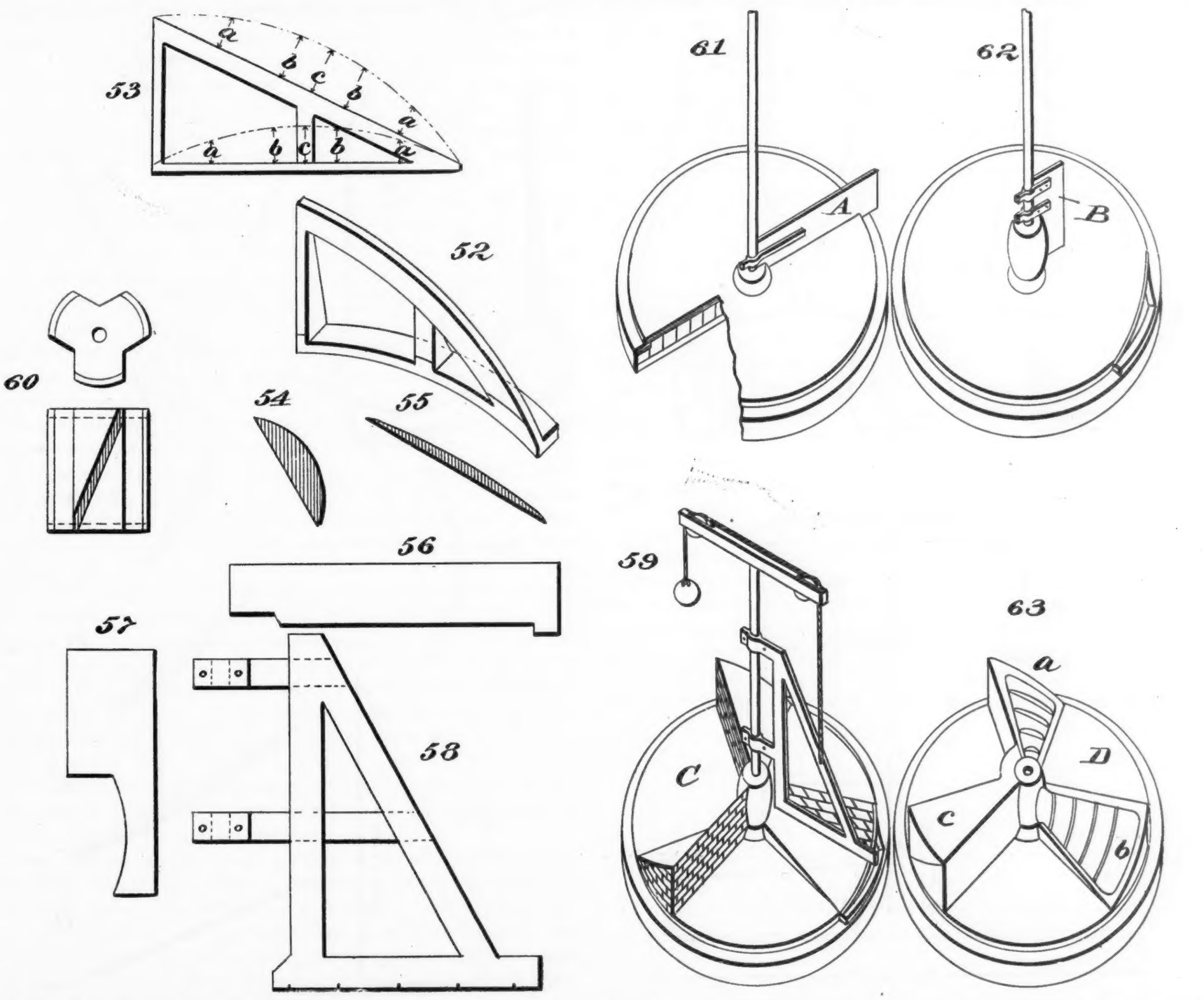


Fig. 54 is a thickness piece representing a section of the blade at the first division from the hub, and Fig. 55 represents a similar section, the first division from the periphery. These should be made of pine board about three-fourths of an inch thick, and are curfed with a saw for about three-fourths of their thickness. The curfs are made parallel with the axis of the screw, and the distance between them should be such as to permit the thickness pieces being bent to the line marked for them on the pier by the notches in the blade face sweep. The thickness pieces are secured to the piers with nails.

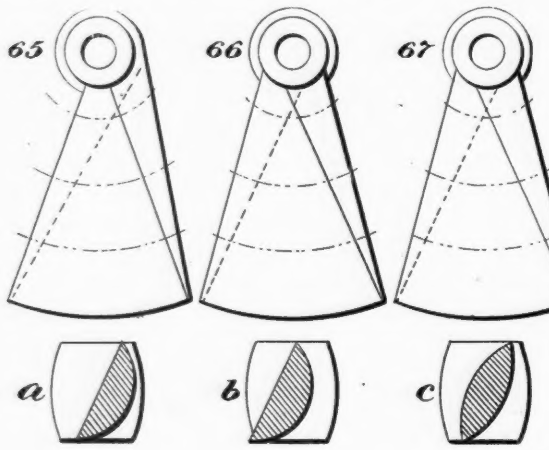
Fig. 56 is the sweep for the foundation, or seat; Fig. 57 that for the hub, and Fig. 58 the sweep for the generatrix or face of the blades. Sweep Fig. 58 is made of plain board about 1¼ inch thick. The generatrix, or working edge of the sweep, is made of various shapes, according to the ideas of the designer. In the present case, it is a right line perpendicular to the axis of the

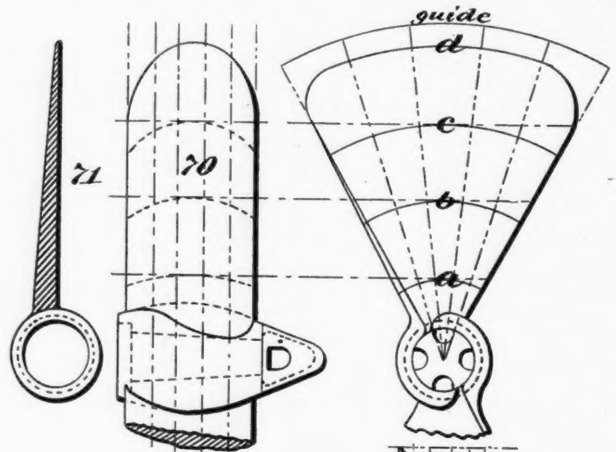
screw. The distance between the hub and the periphery is divided into as many parts as there are thickness pieces to be used. At each division on the sweep a small notch is cut in the working edge; these notches leave a marked line on the face of pier, by which the thickness pieces are set.

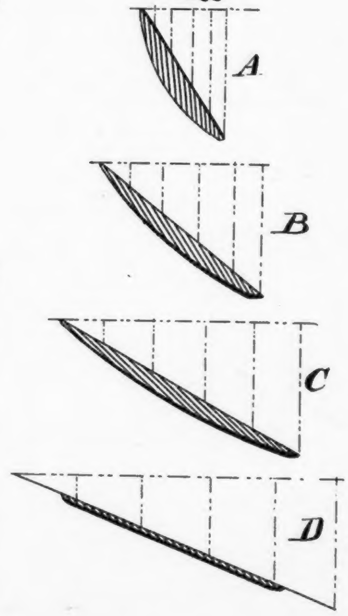
The sweep, Fig. 56, forms an elevation, or seat, on which the hub rests, and also a depression at the outer end, on which the guide sets. After the seat has been dried, it is lined off according to the number of blades required. The sweep, Fig. 57, forms the pattern for the hub, which is usually built of brickwork, and covered with loam, and shaped by revolving the sweep around it. The guide is next set in its proper position and weighted, to prevent it moving. The sweep, Fig. 58, for the face of the pier on which the blade pattern is built, is now placed on the spindle and counterpoised, as illustrated at Fig. 59, to permit of its free movement up and down the spindle. The arrangements are now complete for the building of the pier to be commenced.

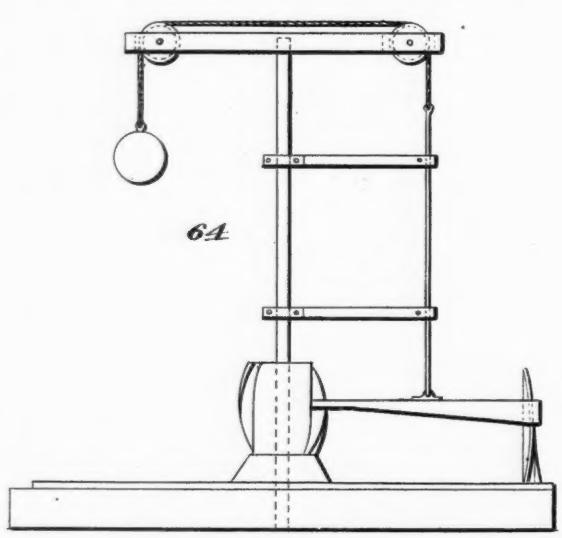
It is necessary that the sweep, Fig. 58, should move by the hub to a small distance below the lower edge of the blade. The up and the guide set. Fig. 59 illustrates two piers completed and one in course of building. At Fig. 63, *a*, illustrates one pier as lined off with the thickness pieces in position. Another pier, *b*, is shown, with the pattern of the blade formed by filling in sand between the thickness pieces and dressing it off to the shape of the blade. The other pier, *c*, shows the cope, or upper part of the mold, which covers the blade completed upon it. After the copes are all completed, the mold is taken apart and stripped of the patterns of the hub and blades.

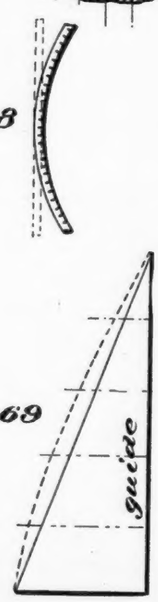
When a sweep at one end follows the axis and the other end the guide, the pitch will be uniform radially. It is sometimes desired to have the pitch variable in a radial direction or a less pitch at the axis than at the periphery. In such a case the sweep is required to travel with a lower axial velocity at the hub than at the periphery. At Fig. 64, illustration *x*, a device is shown by which this can be accomplished. The proper guides are provided at the hub and periphery. Two arms, each having a hole in its end, are secured to a spindle, which is free to turn with the arms. A rod is made to slide freely up and down through the











sweep is thus left at this part without support, and it will invariably spring and finally cause the face or the pier to become somewhat distorted near the hub. To remedy this it was the practice of the writer to provide guides at the hub, as well as at the periphery. These are shown at Fig. 60. If the screw is a small one, a half hub, with the guide cut in it, may be used and shifted around for the several blades. If the screw is a large one, a framework of wood, having as many cylindrical faces as there are blades, is provided. It is made somewhat less in diameter than the least diameter of the hub. A curfed strip is nailed on each of the cylindrical faces at the required angle according to the radius adopted, and these form the guides for the inner end of the sweep Fig. 58. When this arrangement is used, nails are driven into the cylindrical faces, to hold the loam with which it is covered; it is reduced to size and shape by a hub sweep. When sufficiently dry, the loam is cut away, to expose the guides.

Fig. 61 illustrates the seat completed; Fig. 62 the hub swept holes in the arms. The sweep is pivoted to the lower end of the rod and its ends made to bear on the two guides. The height of the blade at the hub and at the periphery being determined, with a proper allowance for the guide being beyond the periphery of the blade, the distance on each guide is divided into the same number of equal parts. Consequently, the vertical distance of a space on the hub guide will be less than one on the peripheral guide. The sweep is then made to travel through a space on the hub guide and a space on the peripheral guide in the same time. The other arrangements necessary to complete the mould are similar to those previously described.

The foregoing is descriptive of the method of preparing moulds for propellers where the thickness of the blade is all on one side of a radial line. In some cases the thickness is given on both sides of a radial line equally, similar to a V thread; in other cases the thickness is unequally divided by such a line.

When the thickness of the blade is all on one side of a radial line, the generatrix is the line exposed by a plane cutting the

screw parallel with and passing through the axis. The plane of the sweep must lie in the same plane as that cutting the screw.

It is possible to generate the face of a screw by the line exposed by a plane cutting the screw perpendicularly to the axis, the sweep lying in the same plane; but the vertical plane for the sweep is preferable.

When the thickness of the blade is divided by a radial line, the generatrix is the line exposed by a plane cutting the screw parallel with but passing outside of the axis, the degree of obliquity depending on the way in which the thickness is divided.

When the generating line is not a right line perpendicular to the axis of the screw, but a line of unusual form, occupying some peculiar position with reference to the axis of the screw, it becomes quite a difficult problem to work out the line on paper. The writer has found it convenient to work this out, as well as many other tedious problems, to a scale on white pine blocks, and then develop the line from the one resulting.

What is meant by the thickness being on one side of a radial line is shown by Fig. 65, page 76, where the thicknesses are exaggerated. Fig. 65 is a plan view, and *a* a section of such a blade. Fig. 66 is a plan view of a blade where the thickness is on both sides of a radial line, the face of the blade being flat or straight; *b* is the section of the blade. Fig. 67 is a plan view of a blade where the thickness is also on both sides of a radial line, but the face and back of the blade are convex alike; *c* is a section of the blade.

When the thickness of the blade is on both sides of a radial line and the face of the blade is flat, as shown at 65 and 66, either of the devices shown for sweeping up propellers can be employed, provided the pitch is uniform radially; but when the section of the blade is like that of 67, or when the pitch is not uniform radially, the device shown at 64 is alone applicable. With this device the sweep is fixed at right angles to the rod when the pitch is uniform radially, and pivoted thereto when the pitch is not uniform. When the latter device is used, and the face of the blade is convex, the guide at the hub is so shaped as to produce the required convexity.

Figs. 68 to 71 show a working drawing of a two-bladed screw propeller. The arcs *a. b, c, d* on the plan view are intended to represent sections of the blade at these points. These arcs are developed into straight lines, as shown, and are then projected to furnish the basis of the angles A, B, C and D. The length of the blade measured axially being determined, it is laid off at one end of these base lines and perpendicular to them, the triangles being completed by a hypothenuse drawn between the extremities of each of the base and perpendicular lines. This hypothenuse is the length of the section of the blade developed. The greatest thickness of the blade at each of these sections being determined, it is laid off in the center of the hypothenuse, and an arc of a circle described through the extremity of this thickness dimension and tangent to arcs of one-half inch radius at the ends of the hypothenuse incloses the developed area of the section of the blade it represents.

These sections furnish the forms and dimensions of the thickness pieces. These are made of pine board about three-fourths of an inch thick. Fig. 68 shows a thickness piece which has been curfed with a saw, in order that it may be bent to the required curvature, the curfs being made parallel with the axis of the screw. Fig. 69 shows the angle of the guide, whose base is also the length of its arc developed.

The full hypothenuse line, which is a straight one, is the developed guide line for a true screw, and the dotted line is the guide for a screw of expanding pitch. Fig. 70 is a side elevation of the screw, and 71 is a scale of thickness through the thickest part of the blade. The sections represented should always be given on a working drawing.

When the screw is of expanding pitch, the lengths of at least five ordinates for the curvature of the guide line should be given.

* * *

THERE is no city in the world where the business community looks more carefully after the purchasing power of its dollars, or where labor and money-saving appliances are more quickly taken up, than in Chicago; so that a stranger can't help reflecting when he sees on one of its principal bridges, one man getting ready to start the motor which opens the draw, another ringing a dinner-bell to warn unwary strangers against falling into the river, while two others, one at each end, slowly pull rusty chains across the ends of the street.

CLEARANCE AND COMPRESSION.

HOW THEY AFFECT THE ECONOMY OF A STEAM ENGINE—THE SUBJECT EXPLAINED IN A SIMPLE MANNER FOR PRACTICAL MEN.

F. F. HEMENWAY.

The effect of clearance and compression on the economical use of steam in the cylinder of a steam engine, while not susceptible of rigidly exact demonstration, is nevertheless fairly so. Why the demonstration may not be rigidly exact is because, knowing every condition, the precise behavior of steam in the cylinder cannot be foretold with mathematical exactness. Various conditions may and do affect this behavior, but not to such an extent as to, in scarcely any degree, account for the various opinions so commonly found in print. The direction of both loss and gain in the use of steam are so well understood that conclusions well within the bounds of probability may be reached as to what will become of a given quantity admitted to and discharged from the cylinder of any ordinary steam engine.

Clearance is in itself a necessary evil, representing a direct and absolute loss, which loss cannot be recovered by any juggling with the steam that remains in the cylinder at exhaust closure. It not only cannot be recovered, but it cannot be appreciably modified; notwithstanding we are told that all we have to do to quite neutralize the loss is to carry compression up to the point of initial pressure.

Compression is in itself almost or quite an absolute necessity, but its effect on economy in steam using is rather enormously overrated.

What follows is not for engineers accustomed to the every-day use of mathematical formulas, but for that more numerous class who, while not entirely shunning mathematical demonstration, are better suited when such demonstration is shown to be correct by graphical illustration. I confess never to have used the plan in all its simplicity before, which makes it neither better nor worse. Perhaps a better head-line would have been "Clearance and Compression Graphically Considered," or something of the sort.

HOW THE DIAGRAMS ARE PLOTTED.

For plotting the expansion and compression curves—this is written for those whose investigation has not been in this direction, and may be skipped by others—it is only necessary to keep in mind that the height varies inversely with the volume; that is, if one volume of steam is permitted to expand so as to occupy two volumes of space, the height to a point in the curve will be only half as great. Thus, if with a given volume the height is

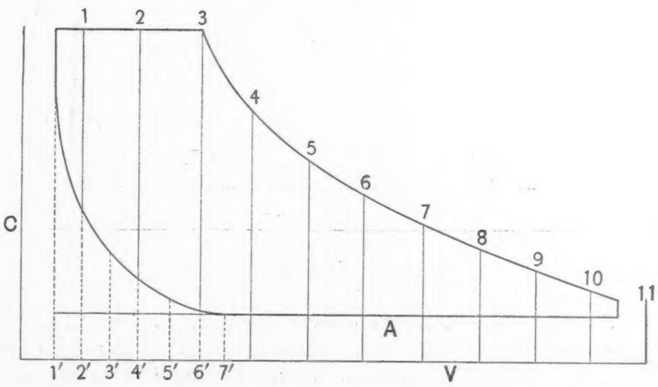


Fig. 1

1 inch at two volumes the height will be ½ inch, and so on. Conversely, if at two volumes the height is ½ inch, when the two volumes are compressed into one the height will be 1 inch. Heights must be measured from vacuum, V (Fig. 1), and volumes from the limit of clearance, C.

The curves herewith were plotted as represented in Fig. 1. For the expansion curve 11—the number is immaterial—equidistant lines 1, 2, 3, —11 were erected. The line 3 is at the point of cut-off. The height to the beginning of the expansion curve (the length of line 3) is 1.75 inch. To find the length of any other line (from V to a point in the curve) multiply 1.75 by 3 and divide the product by the number of the line whose height is

required. Thus the height of line 6 is $\frac{1.75 \times 3}{6} = .875$ inch (⅞ inch), and so on for all the lines after 3*.

For the compression curve broken lines $1^1 - 7^1$ were erected, the distance from C to 1^1 being the distance added to the diagram to represent the clearance space, in this instance 5 per cent., or .15 inch. (The clearance in the cylinder of a steam engine is all the space in the cylinder from the piston at the end of its stroke up to the valve face. The per cent. of clearance is the amount this space would add to the length of the cylinder if reduced to terms of its diameter.)

The compression curve is drawn from line 1^1; the height of this line is 1.75 inch; the height of line 2^1 is $\frac{1.75 \times 1}{2} = .875$ inch, and so on to line 7^1. Points in either curve can be located from any of the lines in reference, as will be readily seen from a consideration of the fact that the product of the height of any line and its distance, measured to the clearance limit, is equal to the same product obtained from any other line.

WHAT THE DIAGRAMS REPRESENT.

The diagrams that follow might be supposed to be indicator diagrams, which they are not. They are simply pressure diagrams, constructed in the simplest manner possible. They bear a general resemblance to indicator diagrams because the latter are only pressure diagrams. The line A is the line of atmospheric pressure, and V is the line of vacuum, or no pressure, which is assumed to be 15 pounds below atmospheric pressure, that is the pressure of the atmosphere is assumed to be 15 pounds per square inch, which it is at the sea level, very nearly.

The shaded portions of the diagrams represent work areas. As they are supposed to have reference to an engine working steam non-condensing this area—the area of useful work—is all above atmosphere. Perfect conditions are assumed in all respects, the drop in pressure being instantaneous at exhaust opening, and the exhaust line—the back pressure line—is coincident with the atmospheric line.

The work area in all the diagrams is 3 inches in length, and its greatest height is 1.75 inch, which height corresponds to a pressure of 90 pounds, by gauge. The small size of the diagrams comes from considerations of convenience in printing. For the purpose of calculation they should be drawn much larger, say three times the dimensions given.

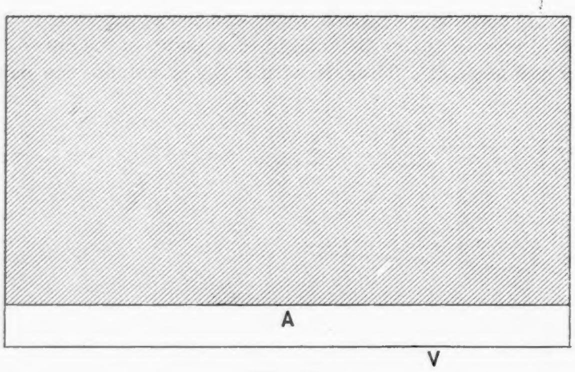


Fig. 2

Referring to Fig. 2, it represents the work that would be done in the cylinder of a steam engine (without reference to size) under the conditions named. Steam is supposed to be worked absolutely full stroke, and the steam expended is represented by the length of the diagram, 3 inches. For convenience we may make units of our own. Call one inch of length of diagram the unit of steam used, and one square inch of work area the unit of work done. The work area is $3 \times 1.5 = 4.5$ inches; for each unit of steam used there has been $4.5 \div 3 = 1.5$ units of work done. This is the best possible result that can obtain in the instance of a non-condensing engine working under the conditions named.

* As the notation will be in decimals, the operative engineer or mechanic having only ordinary instruments for measuring should provide himself with a table of decimal equivalents (to be found in most engineers' pocket-books.) Suppose the height of line 9 is wanted. It will be $\frac{1.75 \times 3}{9} = .583333$ inch. A glance at the table will show that 37/64 inch will be within about 1/200 inch of right; a little allowance can be made for this, and the height of the line will be found, practically correct

CLEARANCE WITHOUT EXPANSION.

Assume now that there is 5 per cent. clearance, represented in Fig. 3 by space C, = .15 inch in length. Five per cent. more steam is now used, and it adds nothing to the work area. The direct loss from clearance—the loss that can be exactly accounted for—is 5 per cent.

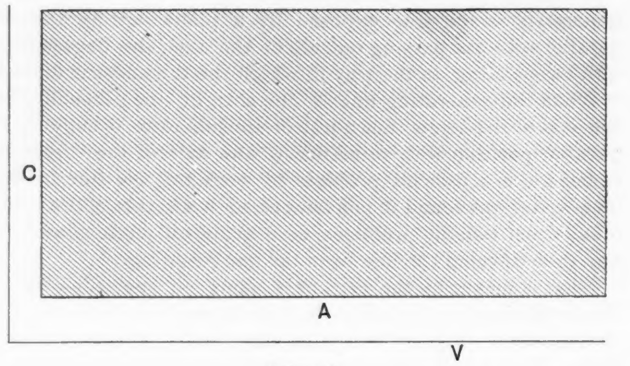


Fig. 3

In Fig. 4 the clearance is the same as in Fig. 3, but compression has been brought about until the clearance space is filled with steam of initial pressure. There is now no steam required from the boiler to fill this 5 per cent. clearance. Five per cent. less steam is used, but this represents no saving. Careful measurement of the space S, cut off by compression, shows that the work area is reduced by 5 per cent.; 5 per cent. less steam does 5 per cent. less work. So far as we are just now considering the matter the account is even. The direct loss from clearance is still 5 per cent. There has been no direct gain from compression because there has been no work done by the compressed steam. There can be no work done by it except through using it expansively. Clearance in a full stroke engine is a loss represented by its amount. Compression *per se* does not affect the matter one way or the other.

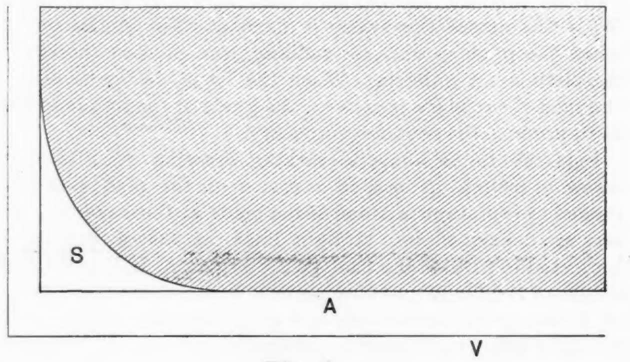


Fig. 4

CLEARANCE WHERE THERE IS EXPANSION.

Fig. 5 represents what might occur in the same cylinder with neither clearance nor compression, steam being cut off at one-quarter stroke, that is .75 inch of steam being used. The work area is reduced from 4.5 inches to 2.38. One unit of steam now does $2.38 \div .75 = 3.17$ units of work.

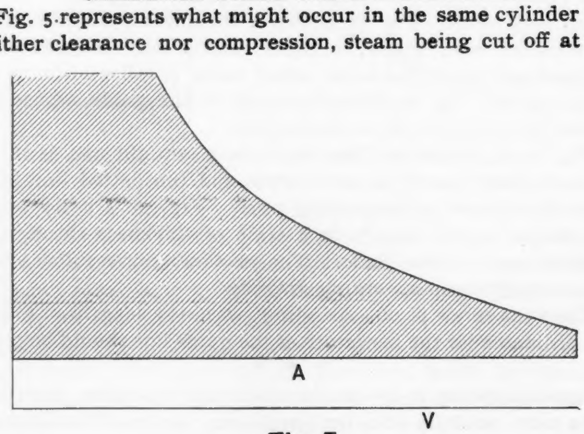


Fig. 5

Add 5 per cent. clearance as represented in Fig. 6, the cut-off being the same as in Fig. 5. The work area is now 2.53 square inches, but the quantity of steam used has been increased by the

amount of the clearance space. It is now $.75 + .15 = .9$ inch. One unit of steam now produces a work area of $2.53 \div .9 = 2.81$. square inches. This is an apparent loss of more than 11 per cent. This additional loss is due to less expansion. The ratio of expansion, instead of being $3 \div .75 = 4$, is $3.15 \div .9 = 3.5$. If expansion were increased so that the work area was the same as in Fig. 5, the loss would be that due to the clearance only, viz., 5 per cent. of the piston displacement.

Fig. 7 represents the same conditions as Fig. 6, except that compression is up to initial pressure. The work area is reduced to the extent of .225 square inch. It is now 2.305 square inches. The clearance space is filled with steam at initial pressure. Only .75 inch of steam is taken from the boiler. If we accept the figures as they stand we should conclude that the loss from

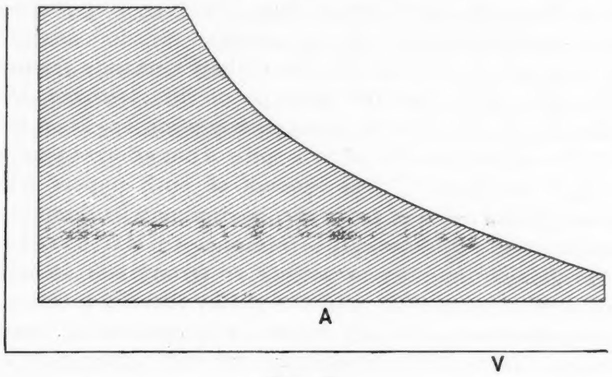


Fig. 6

clearance was almost entirely recovered by compression; this is very commonly taken as being so.* Comparisons of this kind are of no value whatsoever except the work done is the same in the instances of which comparison is made. This is not the case here, nor is it generally so in comparisons made for the purpose of demonstrating the gain by compression. If now we construct another compression diagram, in a way which has been sufficiently indicated, in which the work area is the same as in Fig. 5, we shall find that instead of the loss from clearance being overcome by compression, it still remains a positive quantity notwithstanding; more than this we shall find that, as steam engines are ordinarily operated, and always when they are economically operated, there is, so far as we can apply exact figures to the matter, a slight loss from compression.

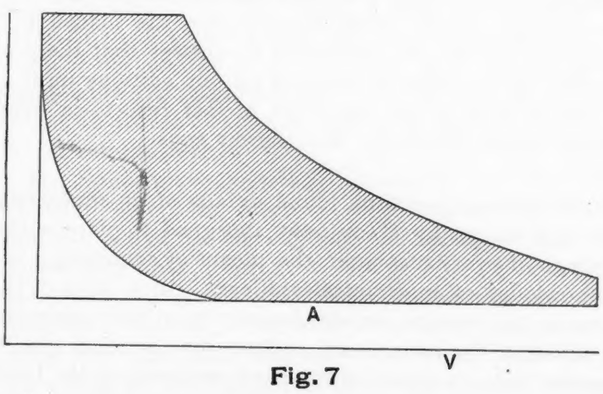


Fig. 7

INDIRECT GAIN FROM COMPRESSION.

There is undoubtedly some gain from compression—indirect gain—which, while not in extent calculable, is in direction apparent; other savings claimed for it will scarcely bear close scrutiny: saves loss from condensation of the entering steam; fills the clearance space without going to the boiler for it, etc., are the standard arguments in favor of compression. A sufficient answer to the first of these arguments is that the loss in the cylinder of a steam engine is not from the condensation of the incoming steam, but from its subsequent re-evaporation at a time when it can do little or no work, as late in the forward and during the return stroke. Any amount of compression cannot prevent this re-evaporation. But, it is reasoned, condensation furnishes the water for re-evaporation. In answer to this it seems enough to say that in the cylinder of any steam engine, more especially if steam is worked expansively, the boiler producing saturated—just dry—steam, there is always present more water, just in the condition and place to absorb heat, than can by any possibility be re-evaporated. This being the case it would not seem to matter much whether the excess is a little more or less, so long as it does not obstruct the progress of the piston, which will not be the case; it will not be the case unless the steam furnished by the boiler, instead of being dry, is surcharged with water. As to saving steam from the boiler, it does not do this, but rather the reverse; compressed steam does not, as shown, give back the work put into it during compression.

Another argument is that it tends to smooth running. This is true, beyond question. We may go farther and successfully claim that this means, to a very moderate extent to be sure, and generally, a saving of steam. For an engine that pounds is rather certain to heat, which means that some of the heat which ought to produce motion is worse than wasted in producing a rise of temperature.

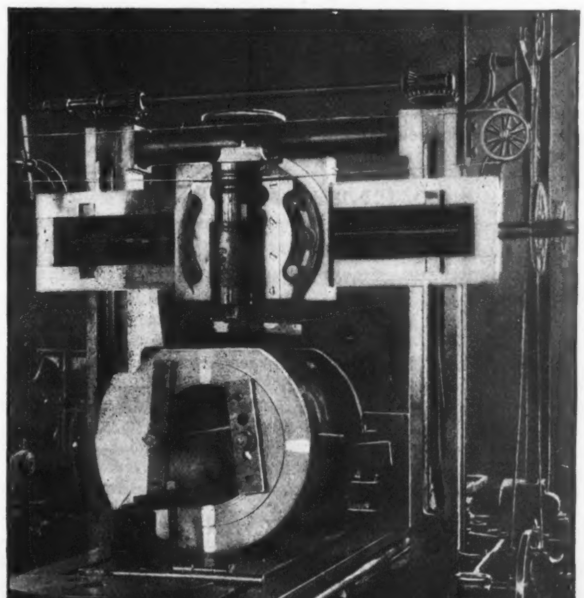
The inevitable conclusion seems to be that there is no way of directly overcoming the loss from clearance, and that indirectly the loss can be no more than partially at the best, modified by compression. The only practical way to modify this loss, to an appreciable extent, is to reduce clearance as much as is practicable. Incidentally, doing this reduces the surface to be reheated whether the reheating is wholly by the condensation of steam at admission or in part by compression.

* Upon this showing the loss would be quite recovered were it not for the fact, which ought to be apparent, that the compressed steam cannot do work equal to that expended in compressing it unless expansion is quite down to the line of counterpressure, which in this instance is the line of atmospheric pressure.

* * *

A "JIM CROW" TOOL HOLDER.

The accompanying illustration is from a photograph that we received through the courtesy of Mr. W. V. Gould. It represents an old screw-driven Whitworth planer, built in 1839, and fitted with a "Jim Crow" tool holder, which reverses the tool at each end of the stroke and enables the cut to be taken in both directions. The machine is owned by Messrs. Jas. Simpson & Co., Ld.. Pimlico, London. S. W. Just why the name "Jim Crow" should be attached to a reversible tool holder we are unable to state, but such is the fact, and we should be pleased to have an explanation from some English reader. The tool holder is reversed through ropes connected with the feed mechanism and is said to work well when the ropes are in good condition (which they often are not), and then a boy is used to keep the tool turning and lessen the likelihood of a ruined piece of work.



"JIM CROW" TOOL HOLDER.

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AMERICAN MACHINERY IS THE TITLE OF THE FOREIGN EDITION OF THIS JOURNAL, WHICH IS PRINTED ON THIN PAPER AND COMPRISES ALL THE READING MATTER AND ADVERTISING IN THE DOMESTIC EDITION. THESE TWO EDITIONS INCLUDE THE LARGEST CIRCULATION OF ANY PUBLICATION IN THE MACHINERY TRADE.

NOVEMBER, 1897.

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AMERICAN MACHINERY.

About three years ago when this publication was established and the title MACHINERY chosen, we supposed there was no other paper of that name in existence. During the second year of publication, when our circulation in Great Britain began to increase, an English paper named *Machinery* claimed, and with justice, that we were infringing upon its right to the use of the name in that country, although the appearance, character, and reading matter of the two papers were as different as English and American machine shop methods. But in order to distinguish this paper beyond question from our English contemporary, we began the use of the prefix AMERICAN on all papers sent abroad, so that AMERICAN MACHINERY is now the appropriate and expressive title of our foreign edition.

The reasons for our use of this title we believe to be well known to the management of the *American Machinist*, and it was therefore with considerable surprise (especially after reading in a late issue, "*The American Machinist* is the only paper of its kind published") that we received without previous communication the following letter:

CARL A. HANSMANN,
ATTORNEY AND COUNSELLOR AT LAW,
96 BROADWAY AND 6 WALL STREET,
NEW YORK, September 24, 1897.

To the Publisher of MACHINERY:

DEAR SIR: For some time you have been using the title AMERICAN MACHINERY for a greater or less part of the edition of your publication MACHINERY. On behalf of the *American Machinist*, I beg leave to give you notice that the use of the said title is a violation and infringement of the well established rights of the *American Machinist*, and that its use must be stopped forthwith and no other title used which simulates the name *American Machinist*.

Very truly yours, CARL A. HANSMANN.

Most business men when they discover a grievance against a neighbor first call his attention to it in a friendly way, and do not resort to the law if their demands are met in the same spirit; but the attitude of the *American Machinist* towards MACHINERY since its inception has been distinctly the opposite of friendly, in spite of our efforts to maintain such relations. Those readers of both papers who have continued with us from the beginning will doubtless remember our contemporary's reference to MACHINERY in its early days when it was neither so strong nor so well established as at present, and the policy thereby indicated we very much regret to say did not end with the old management. It should be evident to our competitor that its long and profitable monopoly is ended, that MACHINERY is in the field to stay, and that neither this attack nor others less open, which we have so far disregarded, will drive us from it or impair our standing.

Had the management of our contemporary approached us in a friendly way, without the unnecessary interference of the law, we would have made it clear that the exterior of the two papers was alone so radically different as to refute their assertion in the eyes of any unprejudiced person. The *American Machinist* comprises, usually, 48 pages 9 x 12, while MACHINERY comprises, including the cover, 68 to 74 pages 9 x 13; and in size, weight and number of pages is so entirely different from the *American Machinist* that no blind man can possibly mistake one for the other.

But as our contemporary has chosen to call on us with a club instead of an olive branch, we are placed in a position where we are compelled to answer that the present titles will continue to be used on our editions until we are forced to stop by the court of last resort—in every country where AMERICAN MACHINERY goes.

* * *

ON another page will be found details of an educational work undertaken by MACHINERY, designed to place within the reach of every mechanic the means of acquiring a better knowledge of mechanical subjects. In a work of this character the results depend largely upon the experience and ability of the instructors, and we are therefore glad to announce that its direction has been assumed by Mr. Louis Rouillion, who is admirably qualified for the undertaking by his training and experience as an instructor.

THE CASE OF JOHN WEDDERBURN.

We have received the full text of the reports of Commissioner Butterworth and Assistant Commissioner Greeley, recommending that John Wedderburn & Co. be disbarred from practicing before the Patent Office, and which were approved by Secretary Bliss, September 30. If any one wishes to read the details of one of the most artfully conducted schemes on record for filching money from the uninformed but credulous public, let him apply to the Commissioner of Patents, Washington, D. C., for a copy of these reports. Green goods men are bad in their way, but they sink into oblivion beside the practices of these enterprising patent solicitors. The methods of both are to be ranked in the same class, however, inasmuch as both con

sist in convincing people that it is an easy matter to get wealth from nothing if they go about it in the right way. In the case of Wedderburn, the scheme was worked through a system of advertising, correspondence, medals, prizes. write-ups, etc., and resulted in inducing tens of thousands of people to believe that fortunes awaited the inventors of any one of a thousand simple articles, if rightly handled—that is, if handled through Wedderburn & Co. The result is that of 33 000 clients, less than 1 600 applications have been allowed; Wedderburn has the money for pressing the claims and the fortunes are yet to be heard from.

This does not put the matter in its worst light, however. A patent lawyer, if honest, will give honest advice regarding the value of a patent; and his standing is not determined, therefore, entirely by the number of claims allowed. The utility of the inventions and the strength of the patents must be considered. It would be interesting to know how many of Wedderburn's 1 600 patents would pass under this test.

* * *

We note that a course of instruction in cost systems and industrial management is being developed at the Massachusetts Institute of Technology under the able direction of Prof. Schwamb. This is a step in the right direction. It will not only give the young men a foretaste of some of the perplexities of industrial work, but it will afford a training in what appears to be a new field of labor. This subject is a study by itself, and manufacturers are coming to appreciate the fact to the extent of employing men to attend solely to this branch of their business.

MACHINE SHOP FITS.

The first article in this issue, by Mr. Arthur A. Fuller, is a valuable addition to the matter which has previously been published in these columns upon the subject of force fits. It not only contains tables of force and running fits, and limits for hole sizes which have been established after much study and observation, but goes a step further and describes a system of gauges whereby those standards have been introduced into every-day shop use. The spherical end reference rods, which are a part of this system, appear to us to embody more good features than any other form of rod; in fact, it would seem that the only possible suggestion for improvement would be that a covering be added to prevent expansion in handling, and there might be objections to that.

Mr. Fuller presents strong arguments for using definite terms in describing machine shop fits, and to this end is an advocate of the limit system of measurements. While some may hold different views on this latter point, we believe that it is the end toward which the best modern practice is tending. The time was when a piece of good work was one that was carefully fitted, piece to piece according to the judgment of an experienced mechanic. In a newer and broader sense, a piece of work, to be good must not only be mechanically good, but commercially good. The constituent parts must be made in different departments of the works, often in large quantities, and in any case without fitting one to the other. Certain sizes must be made accurately to dimensions in order to reduce the expense of hand fitting when assembling and to provide for interchangeability. Other sizes require no special accuracy, and refinements here would mean added expense with no mechanical gain. We know of no way by which these modern requirements can be met as well as by the use of limits, which show in definite terms what is wanted.

* * *

Our readers will be glad to see a contribution from Mr. Podunk in this number, and will be still more pleased to learn that others have been promised.

NOTES FROM NOTOWN—19.

TEACHING IMPRACTICAL THINGS—LOOKING AFTER DETAILS—INSURING AGAINST ACCIDENT.

Ichabod Podunk.

I met a young fellow the other day who has charge of the steam end of a large establishment where they make everything from sausage to soap, and knowing him to be a graduate of the best (I 'spose everyone will think I mean theirs) technical school in the country, I remarked that it must be a great help to him to have had his college education. I was a little surprised at his answer, but believe it's worth thinking over, so here goes: "Mr. Podunk," (s'pose he thought 'twould tickle my vanity to be mistered, seein' I had on overalls, grease, etc.), he said, "there are several things about a college education that don't 'gee' when you start out to hustle for your own living. Of course, it's a fine thing—gives me a chance to dig out what information I want with less work than the fellows who get frightened at a few *x y z's—but* (and he emphasized the but), it left lots of hard digging that it shouldn't have done. Let me explain it more clearly.

I left college with the idea that there wasn't much more for me to know, and could make a test of a steam engine so fine you couldn't find a flaw with a microscope. Thermal units, adiabatics and stresses were easy—dead easy as the boys would say. I could test boilers, figure out a new valve motion, or design jiggers that could almost talk, but I found these were not in demand.

When I first went to my present position it was a new plant, or was going to be, and they made me 'chief-of-machinery.' Sounds big, don't it? Well, it sounded altogether too big for me before I'd been there a week. I almost got lost in it and then was sorry I hadn't." Why?

"Well, first they wanted me to design and plan the boiler-house and the engine-room; lay out the piping and all connections and fit the plant up in good style. Now, I could test the boilers, engines, etc., after they were in, but as for designing a boiler-house, we never even were told there was one—the boiler being our only object of solicitude. I wanted to tell them to hire a civil engineer, but finally determined I'd do it or bust, and I didn't bust, either; but it was horse sense and close observation of other plants that pulled me through—not the college education.

The next thing was to install a refrigerating plant, and here I was stalled again. The steam end of the concern I could handle, but the 'shivery' end, with its heat extraction and insulation, was new to me. Would you believe it, Podunk—I mean Mr. Podunk—we hardly heard refrigeration mentioned in college.

What did I do? Why, same as you would; got catalogues of all the good makers and studied up the ice question, and it wasn't long before I could talk refrigeration like an old-timer and knew what I was talking about, too. It was the same with several other things—surveying for a wharf and similar work, that I had to learn the same way.

Now, what I kick about is this: Instead of spending so much time in working out tests to seventeen decimal places (which no man ever makes in actual practice), in designing valve motions that will make a pretty indicator card and nothing else, that no one would build if he valued his reputation, why not teach the things a fellow has to do if he is lucky enough to get a job and hold it?

Why not teach just the things a man ought to know, from firing the boilers to planning the whole plant, from coal bins to chimney. Teach enough surveying so that a man can get at least two posts in line and of the same height, and even three are sometimes needed. Teach about looking after steam heating plant; hot air heating; ice making and refrigeration, in fact all the practical things an engineer ought to know. Not teach them thoroughly; can't do that in four years, but start a fellow so he can dig his way out without having to consult catalogues and asking questions which any ordinary mechanic or engineer knows. You're a practical sort of a chap, Podunk, and ought to appreciate these points," and I did.

I had been thinking this over before and was glad to hear from a graduate of the best (?) school on the subject. The foundation ought to be well laid and not built on a few men's ideas of tests machines, motions, etc.

If the colleges would make a course which would resemble the

things an engineer actually has to do, instead of the things he might like to do, I believe they would be doing a better work for mechanics generally.

A few graduates hang out a shingle as consulting engineer and wait in vain for customers who want steam tested for microbes, or engines designed to run without steam, or mighty little of it, but the shingles usually rot out and the graduate hunts a job, only to find he could get one a good deal quicker if the college had taught him what employers want to know or want a man to do.

SAY, MR. EDITOR, did you ever go into a shop where the proprietor had the idea he had to attend to every detail, from cussin' tramps to designing engine lathes, and who imagined he was the only business man in town because he knew all the details of his business? Well, if you haven't, just come to Notown and I'll take you to old Bleeker's shop, and if you have any trace of "the look after all the details yourself" idea, I'm afraid it will be rudely shattered.

One of his pet details is "Rules and Regulations" for every imaginable offence. One day his own son wandered into the shop and left the ice water turned on till an apprentice saw it and stopped it. Bleeker saw the water and a new rule was on the wall inside of 17 minutes—he had them on tap: "Care must be taken not to spill water on the floor." Real sensible, wasn't it? Then he has rules about wasting steel and other stock; about being careful around the machinery; about getting out a lathe in so many days, hours and minutes and lots of other fool rules which the men laughed at when they thought of them at all.

I went in there the other day and found all hands in the tool room waiting for Bleeker to harden a tap; "he always looked after such details himself" he told me. If he got a man who could harden them right he would have to pay him a fearful price, and so long as he knew how, he didn't propose doing that. That about fills the bill for him. He does his own detail work to save money and know what's going on.

It may have been kinder mean, but I couldn't help asking him how long he had been saving money this way. "Ever since I've been in business, bout 25 years, and I reckon I've saved a thousand dollars a year, sure." "Twenty-five thousand dollars," I repeated. "Where do you keep this hid away, Mr. Bleeker?" but Bleeker couldn't tell me. His whole shanty, tools and all, wouldn't bring a thousand dollars, and the thousands of dollars he has saved—in his mind—has been wasted in other ways. His continued meddling with his so called "details," most of which could be done by any decent mechanic, takes all his time, lessens the output of his one-horse shop, and sends the best trade to the other shops.

He thinks of "details," such as saving scrap, wearing the sweeper's broom evenly, patching up oil cans and monkey wrenches (when new ones can be bought for the money the repairs cost), and buying the cheapest files on the market. He insists on directing personally the erection of every machine, mixes the paint so that it will "harmonize" with his artistic ideas, and keeps the whole shop waiting while he decides whether to use a ⅜ or a ½ inch bolt on a temporary job where either would answer equally.

When a man thinks "details" to such extremes, he doesn't think anything else and he spends dollars worth of time looking after a 10 cent detail that it doesn't make any difference how it is done, so long as it *is* done. A man's think tank can only hold about so much think, and a 10-cent think often takes as much time and energy as a dollar idea; but the man who gets used to the low-priced thinks, can't get down to business on the ideas that pay.

According to my way of thinking, the successful man leaves the cheap thinks to his help, and after he gets some one who can look after details, he devotes his time to the ideas that pay—the ones that push his business—enable him to keep tab on the work, the men and the business, and not to run his thinker dry on such things as mixing paint or testing whiskey for the hydraulic jacks.

Mr. B. (not Bleeker, our Mr. B.) asked me the other day if I had heard of the new scheme to insure the men in the shop against accident. I hadn't and asked him about it. "Well," he said, "this company pays the Employers' Insurance Company so much money, and if any of the men, you for instance, get your leg smashed, your ribs caved in, or your head jammed into next week, the insurance company settles the bill."

I began to get riled up. I had known of a similar case and knew Mr. B. didn't realize all the benefits(?) of the scheme. I told Mr. B. I knew all about the scheme, too much, in fact, and couldn't help going on with my little tale of woe concerning it. I said: "Mr. B., s'posin' I'm out there by the big lathe and one of the loose pulleys decides to see whether a Podunk has any brains or not. Comes sailing down in a paregoric curve and lays me out for awhile. If this company hadn't hired the insurance concern to stand between them and the men—sort of buffer—they would pay me my wages while I was laid up and probably pay the doctor, too, because they know that the old countershaft hasn't been what it ought to be for some time—shaky in the joints, so to speak.

"But with the insurance company it's different. They have been paid to look after such things, and do the dirty work for them, and they do it to perfection. They have lawyers that can prove the pulley didn't fall, but that I jumped up and struck it and that I had no business to be jumping in working hours, anyway. Then, if that don't convince a jury (for when the insurance company does this kind of business they never give a red cent without a lawsuit), they'll prove that Podunk didn't have any brains and consequently the pulley could have got tangled up in them even if it did fall, or prove anything else they want to. If a company wants to insure its men and not have the men imposed on by the insurance company, they might get a policy for each man, covering accidents in the shop, and give it to him individually. But where a shop hires a company to bluff the men out of any return for a painful and expensive accident by claiming carelessness in being near a boiler that was going to explode, or some such ghost story, it better be called insuring the shop's conscience and pocket book, rather than be palmed off as a philanthropic scheme for the men.

* * *

A PROBLEM IN CONE DESIGNING.

H. M. NORRIS.

The principles of cone designing are so well understood that it would seem there was little left to be said on the subject, but I happened upon a problem recently which is somewhat out of the ordinary, and one requiring much figuring, even though logarithms and slide rule are used wherever possible. It is with the hope that a shorter and more simple method will be suggested that I give the operation employed.

It is desired to design a pair of three-speed feed cones on which the same belt can be used either "open" or "crossed," the angular velocity ratio of the driven cone to be approximately the same in each case.

From the above specifications, it will be obvious that we shall require four steps on both the driving and driven cones which, for open and crossed belt, will occupy the positions shown in figures 1 and 2, respectively. We see, further, that C, being the center of the three steps used with the open belt, must equal C′, and B, the center step of the three used with the cross belt, must equal B′.

Assuming C and C′ at 6½″, and taking the center distance at 17⅛″, we first figure the length of belt required when open upon these steps. The formula for open belt is

$$L = 2C + \frac{11D + 11d}{7} + \frac{(D - d)^2}{4C}$$

in which C = center distance, D = diameter of largest step, and d = diameter of smallest step. Substituting our known quantities, we have

$$L = 2 \times 17.125 + \frac{11 \times 6.5 + 11 \times 6.5}{7} + \frac{(6.5 - 6.5)^2}{4 \times 17.125}$$

$$= 34.25 + 20.4285 + 0$$

$$= 54.6785 \text{ inches.}$$

We next find B which must be of such diameter as will work with B′ with a cross belt of the length just found. Let us assume it at 5¾″. Then, using the formula for cross belts

$$L = 2\left[\sqrt{C^2 - (R + r)^2} + 1.57\,(R + r) + .0175 \div (R + r)\right]$$

in which C = center distance, as before, R = radius of large step, r = radius of small step, and ÷ = angle in degrees = angle whose sine is $(R + r) \div C$, we have:—

$$L = 2\left[\sqrt{17.125^2 - (2.875 + 8.875)^2} + 1.57\,(2.875 + 2.875) + .0175 \sin\frac{2.875 + 2.875}{17.125} \times (2.875 + 2.875)\right]$$
$$= 2\,[16.1311 + 9.0275 + 1.9739]$$
$$= 2\,[27.1325] = 54.2650 \text{ inches,}$$

or $54.6785 - 54.265 = .4135$ of an inch too short.

In dealing with open belts where the assumed diameters of a pair of cone steps figure too small to suit a certain length of belt previously determined, the true diameters may be found by add-

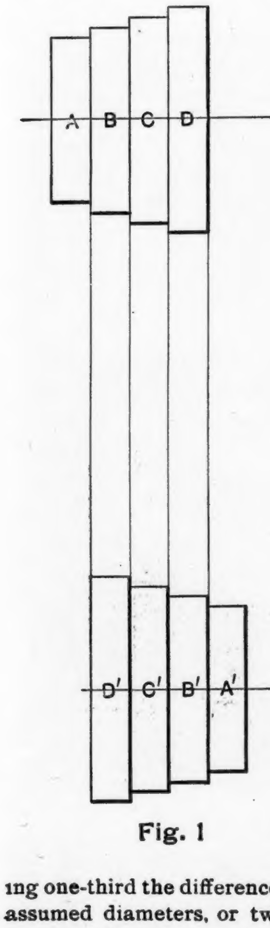


Fig. 1

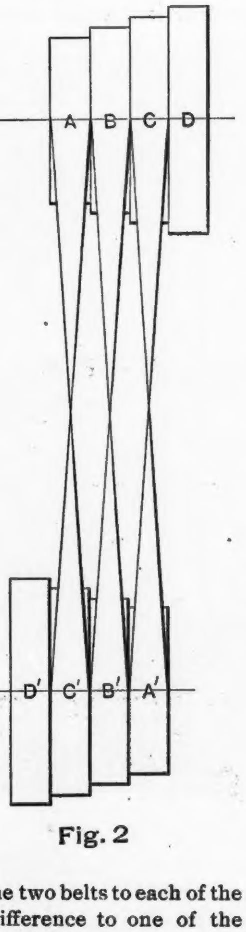


Fig. 2

ing one-third the difference in length of the two belts to each of the assumed diameters, or two-thirds the difference to one of the assumed diameters, as shown by Mr. R. E. Marks in the January number of MACHINERY. But with crossed belts, where a greater amount of the circumference of the pulley is in contact with the belt, it is evident that two-thirds the difference would be too much to add to either of the diameters, so let us try adding only one-half the difference, or one-quarter to each step.

One-quarter of .4135 is .1034 which, added to our assumed diameter of $5\frac{3}{4}''$, gives 5.8534, or a little over $5\frac{27}{32}''$, as the new trial diameter of B. Testing this by means of the above formula, we have

$$L = 2\left[\sqrt{17.125^2 - (2.927 + 2.927)^2} + 1.57\,(2.927 + 2.927) + .0175 \sin\frac{2.927 + 2.927}{17.125} \times (2.927 + 2.927)\right]$$
$$= 2\,[16.0935 + 9.1898 + 2.0469]$$
$$= 2\,[27.3303] = 54.6606 \text{ inches,}$$

which gives a difference of only $54.6785 - 54.6606 = .0179$ of an inch.

Let us next find D which must work with B' with open belt. By inspection we see that the diameter of B', which is equal to B, is .6466" less than the diameter of C', and we know that the middle step of a correctly designed three-speed "even" cone is always in excess of its nominal diameter, or in other words, somewhat greater than the arithmetical mean between the two end steps, so we can safely conclude that the nominal diameter of our cones are $5\frac{1}{4}''$, $5\frac{7}{8}''$, $6\frac{1}{2}''$ and $7\frac{1}{8}''$ respectively. But we have found that B' is 5.8566", or .0184" less than its assumed nominal diameter, so D must be .0184" less than its assumed nominal diameter or 7.1066". Checking by means of the formula for length of open belt, we have

$$L = 2 \times 17.125 + \frac{11 \times 7.1066 + 11 \times 5.8566}{7} + \frac{(7.1066 - 5.8566)^2}{4 \times 17.125}$$
$$= 34.25 + 20.3707 + .022$$
$$= 54.6427 \text{ inches}$$

or within $54.6785 - 54.6427 = .036''$ of our first determined length, and $54.6606 - 54.6427 = .0109''$ of the calculated length of the crossed belt for steps B and B', which is quite near enough.

Since D' = D, and A = A', it only remains for us to find the diameter of A' to work with C with crossed belt. The nominal diameter of this step we have already assumed to be $5\frac{1}{4}''$. Figuring on this basis, we have

$$L = 2\left[\sqrt{17.125^2 - (3.25 + 2.62)^2} + 1.57\,(3.25 + 2.62) + .0175 \sin\frac{3.25 + 2.62}{17.125} \times (3.25 + 2.62)\right]$$
$$= 2\,[16.087 + 9.215 + 2.054]$$
$$= 2\,[27.359] = 54.718 \text{ inches,}$$

or a difference of only .0395" with the belt for steps C and C', which is not sufficient to vary the tension of the belt to any appreciable extent.

This last operation was, however, unnecessary, as A' could have been determined more readily by comparison with the other steps, since its true diameter must bear the same relation to its nominal diameter as the true diameter of D bears to its nominal diameter, or .0184" less. So we see that A' should be 5.25" − .0184", or 5.2316" in diameter which, if used in the above calculation, would show a much smaller difference than found.

Had the problem been to design the cones so that they would only be "even" with an open belt, or "even", only, with a crossed belt, we could omit step A in the first case, and step D in the latter, which would avoid the necessity of shifting the cones through a distance equal to the width of two steps when changing from an open to a crossed belt, or vice versa, as is required in the present incidence.

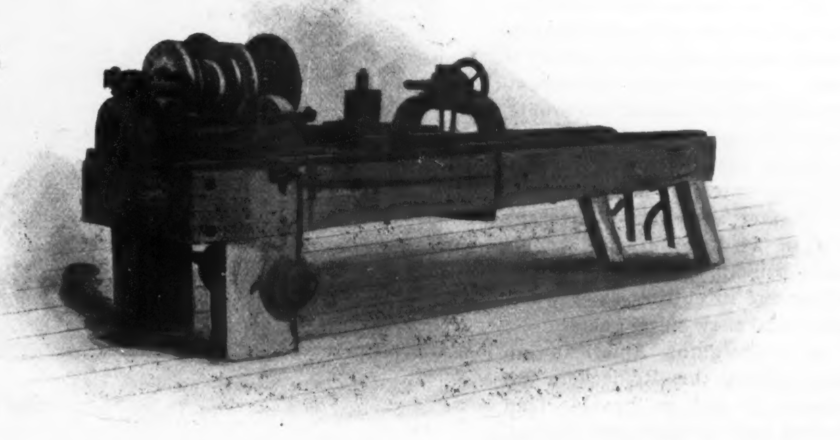
* * *

WHO CAN BEAT THIS?

AN OLD LATHE BUILT AT WATERTOWN, N. Y.

CLARENCE E. KINNE.

Having read with interest several descriptions of old machine tools in your columns, I send herewith a photograph of an old lathe with many years to its credit. It was built by Nathaniel Wiley in 1830, and swings 22 inches diameter and 10 feet between centers. As it will be noticed, it has a rack feed, instead of a chain feed; the rack being movable, was clamped to the carriage according to the length of the work. The shears are cast iron bolted to the wooden frame. In 1820 Mr. Wiley built the first machine shop in Watertown and this lathe was used in his shop from 1830 to 1852, when it (the lathe) was sold to Bliss



BUILT IN 1830.

& Brown of Carthage, N. Y., who used it until 1866, when it was sold for $75. to Mr. Slater of Black River, N. Y. It was used in Mr. Slater's shop until 1889, when it was put out of doors to make room for modern lathes, and is now surrounded by scrap iron and weeds.

[We have had the engraver remove the "scrap iron and weeds" for the sake of clearness.—ED.]

A MODEL SAXON SHOP.

DESCRIPTION OF THE WORKS AND SOME OF THE MACHINES SEEN THERE.

ROBERT GRIMSHAW.

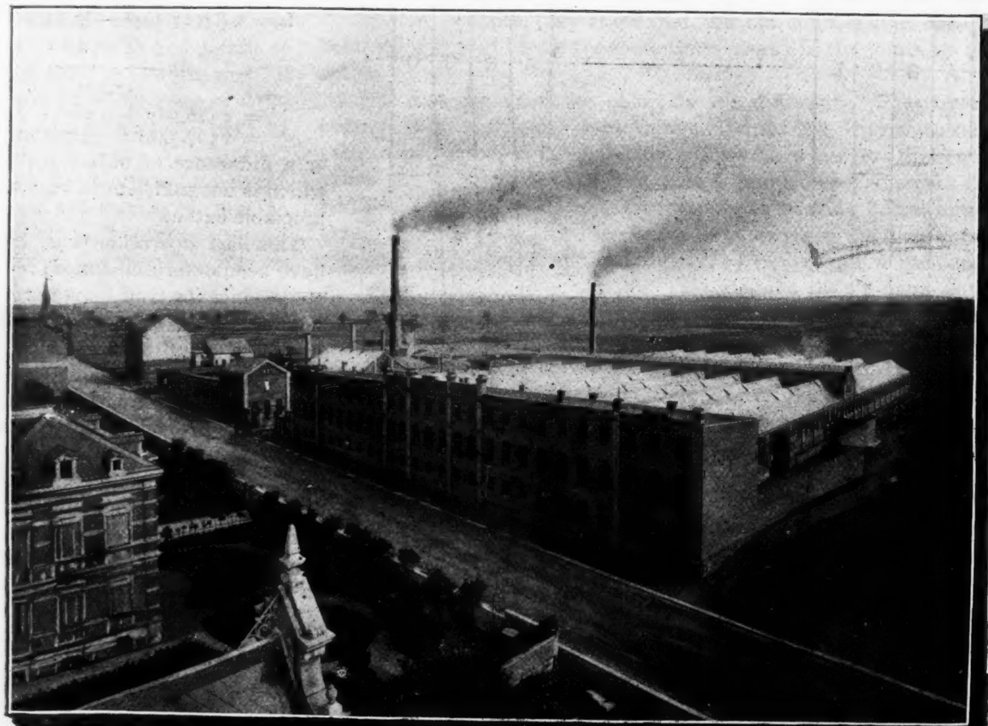
At the shops of J. E. Reinecker, Goblenz-Chemnitz (Saxony) I found 700 men doing their best to keep up with orders, and not succeeding. These shops have been doubled in size and the working force doubled in numbers in the past three years. The buildings are quadrilateral and one-story high, the workshops having a modification of the New England "cotton-mill" roof well white-washed or painted on the under side and with large sky lights—this being necessary or at least highly desirable under the gloomy Saxon winter sky. The machine tools, some hundreds in number, are electrically driven and systematically arranged; each tool having plenty of room all round it for access of workmen. The firm builds all sorts of machine tools very largely of American conception and Germanized execution. Many rows of backing-off or relieving lathes were at work turning out milling cutters and taps, and a full line of machinists' tools such as taps, dies, reamers, gauges, twist-drills, etc., is made. Limit-gauges are made in both English and metric sizes. Taps are cut down as fine as one millimeter = 0.04 diameter, and up as high as two inches. Three Bilgram bevel-gear planers from Philadelphia, were giving a good account of themselves, and three others were ordered; a live American, Mr. Hoffman, being in charge. Brown & Sharpe machines were there in plenty: relieving lathes, universal milling machines, etc. A great deal of fine and good gear work was being done: and one specially good feature was the way of cutting worm wheels by a cutter having the proper outline shaped from the worm itself; the wheel being given rotation as well as the worm-hob, so that the tooth-spaces in the worm wheel could not fail not merely to work perfectly with the worm-threads, when viewed in profile, but to fit the faces of these threads perfectly in convex and concave surfaces instead of merely in lines of contact as with the average worm and worm-wheel. This same principle was employed to advantage in cutting skew worm gears and skew spiral gears.

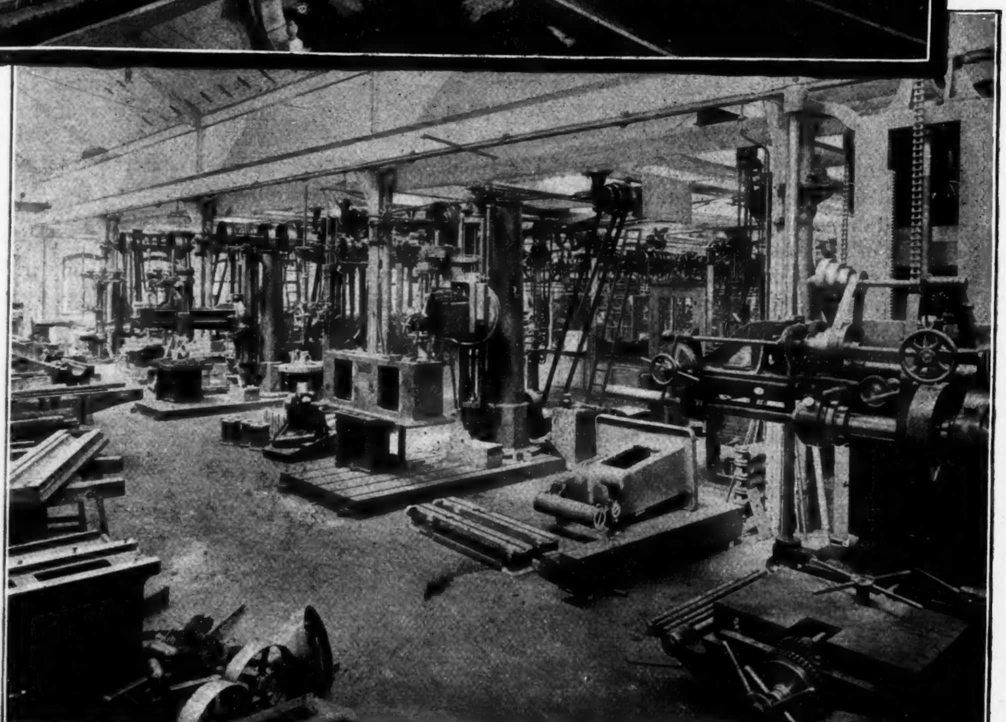
In re-designing American engine lathes, the Reineckers are careful to put in heavier lead screws and to shape out the tail stock so as to permit the slide rest crank to be turned when the rest is clear at the end of the ways.

Electric drive is put on all new machines intended for this shop; that is, where possible, the motor frame is a part of the machine housings, or directly bolted thereto, so that pressure of the foot on a treadle throws the power on. In the shop there is considerable power taken from electrically driven countershafts. Some manilla rope transmission is used.

One planer taking in 60 in. x 60 in. x 20 feet was the standard in the shop; the scraping on its ways, etc., took three months, and the result is so accurate that planer ways planed on this machine require no scraping; in fact, on all the planers in this shop, except this standard one and one other that got a slight twist and had to be scraped, there are no scraper marks to be seen; the planer-tool marks are still visible. The Reinecker planers have flat ways, roller lubrication, and rack motion; with return at four times the cutting speed.

I noted one long horizontal boring machine or drilling machine for drilling spindles up to 80 inches long and 2 inches diameter; this was on the Pratt & Whitney principle, with oil channels in the drill, and forced oil feed to the point.





THE MODEL SHOP OF

There was one veteran Brown & Sharpe milling machine doing good service after many years' earnings; some Garvin machines; a Fifield lathe; two Gisholt grinding machines, a Gould & Eberhardt drill press, and representatives of the Newark and the Niles Companys' outputs; besides a Knowles keyseater.

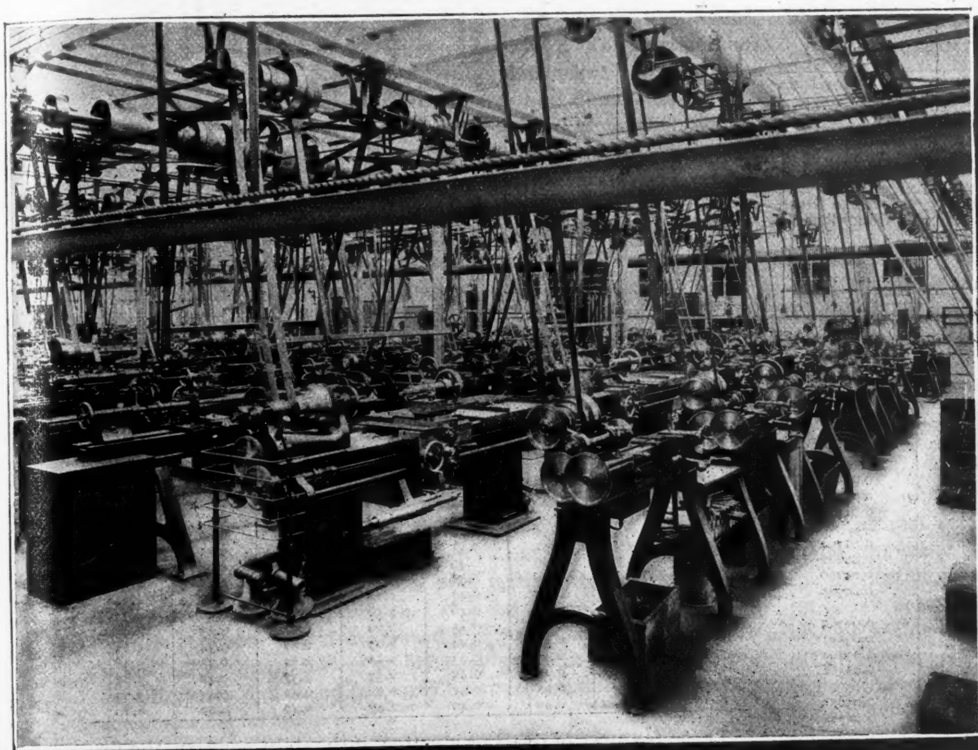
In the center of the shop is the tool-grinding department.

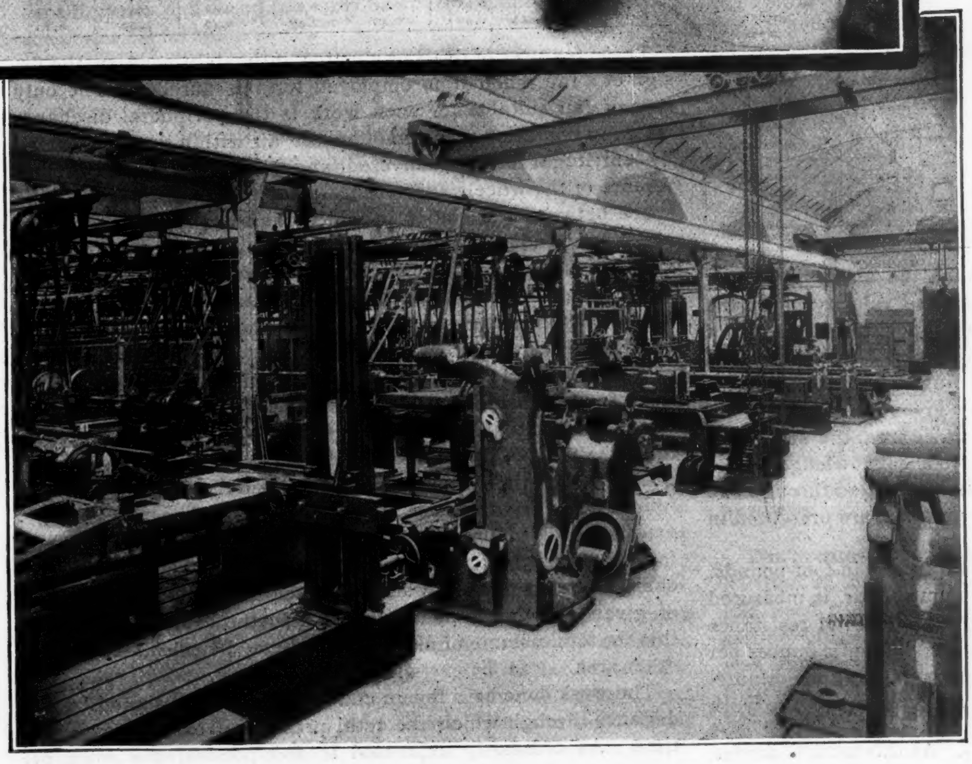
I noticed an ingenious and practical cotton-waste receptacle consisting of a sheet iron tank or tub, approximately semi-

cylindrical, with flat sheet iron lid, and mounted on trunnions so that the contents could be readily dumped into wheel-barrows or wagons at the close of the day; no greasy waste being allowed to remain in the shops over night, as that material has too strong a tendency to spontaneous combustion.

There were thirty or forty backing-off machines at work on milling cutters: and a large number of this class has been sold to consumers and manufacturers of milling cutters.

One machine, which caught my eye in passing by it rapidly, was a "pieced-out" planer; the extension of the ways being borne by brackets bolted on to the flat end of the old bed.





J. E. REINECKER (SAXONY).

The office building is 67x9 meters = 220x30 feet, and three stories high. The main workshop is 60x110 meters = 197 x 361 feet. The smithshop and hardening rooms cover respectively 37x12 metres = 121x39 feet, and 37x10 metres=121x33 feet. The ground covers about 200x200 meters = say 656x656 feet.

There are more than 500 machine tools, including 270 lathes, 80 milling machines, 30 boring machines, 50 planers and about 20 miscellaneous.

Power is furnished by a 150 HP machine; about 100 HP by rope and the rest electrical; and a second engine of 250 HP serves to drive a large dynamo for power and lighting purposes.

What is very remarkable in a German shop is that no beer is permitted about the place, even at meal times and during the breathing spells which are allowed from time to time, There is, however, a very complete apparatus for making "filter" or "drip" coffee in the most thorough manner, and this is furnished at cost to the workmen. The late Mr. Schumacher, of Akron, Ohio, of oatmeal fame, was the only other case I have ever known of a German prohibiting the use of beer to his workmen (he carried it so far that any employee who drank beer even when off duty, got his "little yellow envelope" as being an undesirable man to have about the place.)

* * *

MECHANICAL DRAFT.—4.

WALTER B. SNOW.

The relation required between the intensity of the draft and the rate of combustion is a matter regarding which far too little is known. For a clear understanding of the subject it is desirable to consider briefly the theoretical condition of draft production. The relation between the draft or pressure and the velocity of a freely moving volume of air or gas under its influence, is such that the velocity varies as the square root of the pressure and the pressure varies as the square of the velocity. The pressure, which may be represented by p, is due to the weight of a given column of air of height h and density or weight per unit of volume d. Therefore for a given unit area, $p = h\,d$, and $h = \frac{p}{d}$. If there were no friction, and the air were non-compressible, the speed or velocity with which air under a given pressure $p = h\,d$ would issue from an orifice, would be exactly that which would finally result if a body under the action of gravity had freely fallen the distance measured by the height or head h. Therefore its velocity is determinable by the well known formula for falling bodies, viz.:

$$V = \sqrt{2gh}$$

in which

V = velocity in feet per second.
h = head in feet.
g = acceleration due to gravity = 32.16.

As it has already been shown that $h = \frac{p}{d}$, this formula, as applied to the velocity of movement of air, may take the form

$$V = \sqrt{2g\frac{p}{d}}$$

As the pressure is dependent upon both the height and the density of the air, it is evident that for a given pressure the less the density the greater the height of the column. But the law of falling bodies recognizes the fact that it is the distance fallen through and not the weight of the body that determines the velocity. Therefore the less dense the body the higher the column to produce a given pressure, and the greater the velocity of discharge. From this it is evident that the weight of a gas issuing under a given pressure would be greater than that of a liquid under the same conditions. And conversely the more dense the fluid issuing at a

given velocity the greater must have been the pressure to produce that velocity.

When the pressure is given in ounces per square inch and the density of one cubic foot of dry air at 50° temperature, and under atmospheric pressure, is taken at 0.077884 pounds, the last formula becomes

$$V = \sqrt{\frac{1746659 \times p}{235 + p}}$$

when allowance is made for the compression of the air due to its pressure.

From this basis formula Table No. 17 has been calculated.

TABLE NO. 17.—VELOCITY, VOLUME AND H. P. REQUIRED WHEN AIR UNDER GIVEN PRESSURE IN OUNCES PER SQUARE INCH IS ALLOWED TO ESCAPE INTO THE ATMOSPHERE.

Pressure in Ounces Per Square Inch.	Velocity of Dry Air at 50° Temperature Fahr. Escaping into the Atmosphere through any Shaped Orifice in any Pipe or Reservoir in which the Given Pressure is Maintained.		Volume of Air in Cubic Feet which may be Discharged in One Minute through an Orifice having an Effective Area of Discharge of One Square Inch.	Horse-Power required to move the Given Volume of Air under the Given Conditions.
	In Feet per Second.	In Feet per Minute.		
1/8	30.47	1 828.4	12.69	0.00043
1/4	43.08	2 585.0	17.95	0.00122
3/8	52.75	3 165.1	21.98	0.00225
1/2	60.90	8 653 8	25.37	0.00346
5/8	68.07	4 084.0	28.38	0.00483
3/4	74.54	4 472.6	31.06	0.00635
7/8	80.50	4 829.7	33.54	0.00800
1	86.03	5 161.7	35.85	0.00978
1 1/8	91.22	5 473.4	38.01	0.01166
1 1/4	96.13	5 768.0	40.06	0.01366
1 3/8	100.80	6 047.9	42.00	0.01575
1 1/2	105.25	6 315.2	43.86	0.01794
1 5/8	109.52	6 571.3	45.63	0.02022
1 3/4	113.64	6 817.6	47.34	0.02260
1 7/8	117.58	7 055.0	49.00	0.02505
2	121.41	7 284.4	50.59	0.02759
2 1/8	125.11	7 506.7	52.13	0.03021
2 1/4	128.70	7 722.2	53.63	0.03291
2 3/8	132.20	7 931.8	55.08	0.03568
2 1/2	135.59	8 135.7	56.50	0.03852
2 5/8	138.91	8 334 4	57.88	0.04144
2 3/4	142.14	8 528.3	59.22	0.04442
2 7/8	145.29	8 717.6	60.54	0.04747
3	148 38	8 902.8	61.83	0.05058
3 1/8	151.40	9 084.0	63.08	0.05376
3 1/4	154.36	9 261.5	64.32	0.05701
3 3/8	157.26	9 435.4	65.52	0.06031
3 1/2	160.10	9 606.1	66.71	0.06368
3 5/8	162.89	9 773.3	67.87	0.06710
3 3/4	165.63	9 938.0	69.01	0.07058
3 7/8	168.33	10 099.6	70.14	0.07412

The form of the orifice through which the air passes under pressure has practically no effect upon the velocity. But the volume discharged is largely dependent upon the character of the opening, owing to the influence of the *contracted vein*. The value of the coefficient of contraction being known it is a simple matter to calculate the volume for any given velocity. Or the volume being known for any given *effective* area, the size of the necessary outlet may be determined from a knowledge of the coefficient of contraction. The volumes discharged through one square inch effective area of the given pressure are presented in the fourth column of the table.

The theoretical amount of energy as expressed in foot-pounds, which is expended in moving a given volume of air, is measured by the product of the distance moved and the total resistance overcome. Thus per the table, under a pressure of 2 ounces per square inch, the velocity of issuing air is 7284.4 feet per minute. If the effective area of discharge be one square inch the work done is $\frac{2 \times 7284.4}{16} = 910.55$ foot-pounds. As this work is accomplished in one minute, it is equivalent to $\frac{910.55}{33\,000} = 0.02759$ horse-power. In this manner the last column of the table has been calculated. This indicates only the theoretical horse-power; the actual power will always be greater in proportion to the resistance.

If it be desired to pass through the same orifice a constant weight of air, its velocity must vary directly with its increase in absolute temperature, for its density correspondingly decreases. Furthermore the influence of the density on the head and hence on the velocity has already been alluded to. Therefore the matter of temperature as it occurs in boiler practice, is of great importance in any consideration of the movement of air. The influence of the temperature upon the various conditions of its movement is clearly shown in Table No. 18 for temperatures from 50° to 800°.

TABLE NO. 18.—INFLUENCE OF THE TEMPERATURE OF AIR UPON THE CONDITIONS OF ITS MOVEMENT.

Temperature in Degrees Fahr.	Relative Velocity Due to the Same Pressure.	Relative Pressure Necessary to Produce the Same Velocity.	Relative Weight of Air Moved at the Same Velocity.	Relative Velocity Necessary to Move the Same Weight of Air.	Relative Pressure Necessary to Produce the Velocity to Move the Same Weight of Air.	Relative Power Necessary to Move the Same Volume of Air at the Same Velocity.	Relative Power Necessary to Move the Same Weight of Air at the Velocity in Column 5 and the Pressure in Column 6.
1	2	3	4	5	6	7	8
30°	0.98	1.04	1.04	0.96	0.96	1.04	0.92
40	0.99	1.02	1.02	0.98	0.98	1.02	0.96
50	1.00	1.00	1.00	1.00	1.00	1.00	1.00
60	1.01	0.98	0.98	1.02	1.02	0.98	1.04
70	1.02	0.96	0.96	1.04	1.04	0.96	1.08
80	1.03	0.94	0.94	1.06	1.06	0.94	1.12
90	1 04	0.93	0.93	1.08	1.08	0.93	1.17
100	1.05	0.91	0.91	1.10	1.10	0.91	1.21
125	1 07	0.87	0.87	1.15	1.15	0.87	1.32
150	1.09	0.84	0.84	1.20	1.20	0.84	1.43
175	1.11	0.81	0.81	1.24	1.24	0.81	1.55
200	1.14	0.78	0.78	1.29	1.29	0.78	1.67
225	1.16	0.75	0.75	1.34	1.34	0.75	1.80
250	1.18	0.72	0.72	1.39	1.39	0.72	1.93
275	1.20	0.69	0.69	1.44	1.44	0.69	2.07
300	1.22	0.67	0.67	1.49	1 49	0.67	2.22
325	1.24	0.65	0.65	1.54	1.54	0.65	2.36
350	1.26	0.63	0.63	1.59	1.59	0.63	2.51
375	1.28	0.61	0.61	1.63	1.63	0.61	2.66
400	1.30	0.59	0.59	1.68	1.68	0.59	2.82
425	1.32	0.58	0 58	1.73	1.73	0.58	2.99
450	1.34	0.56	0.56	1.78	1.78	0.56	3.17
475	1.35	0.55	0.55	1.83	1.83	0.55	3.35
500	1.37	0.53	0 53	1.88	1.88	0.53	3.53
525	1.39	0.52	0.52	1.93	1.93	0.52	3.72
550	1.41	0.51	0.51	1.98	1.98	0.51	3.92
575	1.43	0.49	0.49	2.03	2.03	0.49	4.12
600	1.44	0.48	0.48	2.08	2.08	0.48	4.33
625	1.46	0.47	0.47	2.13	2.13	0.47	4.54
650	1.48	0.46	0.46	2.18	2.18	0.46	4.75
675	1.49	0.45	0.45	2.22	2.22	0.45	4.93
700	1.51	0.44	0.44	2.27	2.27	0.44	5.15
725	1.52	0.43	0.43	2 32	2.32	0.43	5.38
750	1.54	0.42	0.42	2.37	2.37	0.42	5.62
775	1.56	0.41	0.41	2 42	2.42	0.41	5.86
800	1.57	0.40	0.40	2.47	2.47	0.40	6.10

These features of draft production intimately concern the design of a fan when it is employed for this purpose. The only type of fan suitable for such work is the peripheral discharge which in operation sets in motion the air within it which, acting by centrifugal force, is delivered tangentially at the outer circumference of the wheel. Air rushes in at the axial inlet to fill the space between the blades in which there is, by the centrifugal action, a tendency to form a vacuum. The degree of this vacuum is dependent upon the circumferential speed of the wheel; and the velocity of discharge through an outlet of proper size is substantially equal thereto. If, therefore, the peripheral velocity of a given fan is that indicated by any given quantity in column 3 of Table No. 17, the resulting pressure for the production of velocity through an outlet of proper size and shape will be practically that which corresponds to the given velocity in the table. From the basis formula employed in the calculation of this table, it is evident that the pressure created by a given fan varies as the square of its speed. The volume of air delivered is, however, practically constant per revolution, and therefore is directly proportional to the speed. The volume discharged under given pressure and velocity through an opening of given effective area is presented in the same table. From this the total volume of air discharged may be calculated for any other area.

The work done by a fan in moving air is represented by the distance through which the total pressure is exerted in a given time. As ordinarily expressed in foot-pounds, the work per second would, therefore, be the product of the velocity of the air in feet per second, the pressure in pounds per square foot and the effective area in square feet over which the pressure is exerted. As the work done is dependent upon the pressure, which varies as the square and the velocity which varies directly as the speed, it is evident that the work, being the product of these factors, must vary as the cube of the speed. This means that if the velocity is doubled the volume is likewise doubled, the pressure becomes four times and the power required eight times as great.

The horse-power required to move air under various pressures and velocities has already been given in Table No. 17. As applied to the case of a fan, the quantities there given being for

one square inch of effective area, must be multiplied by the total effective area through which the fan discharges and also by a coefficient which is the reciprocal of the efficiency. Under no conditions can any device move air with the proportionate expenditure of power indicated in table No. 17, for this value does not include the losses due to frictional resistances of the machine itself and of the air in its movement through the machine and connecting outlet or pipe.

In the design of a fan wheel to meet given requirements, it is necessary to make its peripheral speed such as to create the desired pressure, and then so proportion its width as to provide for the passage of the required air volume. The theoretical volumetric capacity of a fan wheel will depend upon its dimensions and the speed at which it is operated. In practice the actual amount of air will also be largely dependent upon the fact of the wheel being encased, the character and dimensions of the case and the size and resistances of the passages through which the air is conducted. The equivalent of such resistances is in boiler practice usually represented by the grates, the fuel, tubes, etc., and may evidently be so great at times as to very seriously reduce the theoretical air discharge of the fan.

Evidently it is unfair to compare fans when operating under such conditions that these resistances cannot be definitely determined. The simplest and most natural condition is that in which the fan is operated without other resistance than that of the case; that is, with open inlet and outlet. But for proper comparison of different fans, the areas through which the air is discharged should in each case bear some constant relation to the dimensions of the wheels themselves.

It has been determined experimentally that a peripheral discharge fan, if enclosed in a case, has the ability, if driven to a certain speed, to maintain the pressure corresponding to the tip velocity over an effective area which is usually denominated the "square inches of blast." This area is the limit of its capacity to maintain the given pressure. If it be increased the pressure will be reduced but if decreased the pressure will remain the same. The square inches of blast, or as it may be termed, the capacity area of a cased fan, may be approximately expressed by the empirical formula,

$$\text{Capacity area} = \frac{D\,W}{x}$$

In which D = diameter of wheel in inches.
W = width of fan wheel at circumference in inches.
x = a constant dependent upon the type of fan and casing.

An approximate value of x for general practice is not far from 3, but this is to be used only to determine the capacity area over which the given pressure may be maintained. This is not a measure of the casing outlet, which is always greater than the square inches of blast; as a consequence the pressure is lower and the volume discharged is somewhat greater than would result through an outlet having the square inches of blast for its area.

In the considerations of the use of a fan for producing draft, comparison is at once drawn with the chimney. While certain other advantages of the fan over the chimney will be pointed out later, it is well here to compare them as regards their efficiency as a means of creating a movement of air. This is the case i a chimney depends upon the heating of the air and thereby creating sufficient difference between the weight of the column within and that of a corresponding column outside the chimney. The heat thus employed is absolutely wasted, so far as its utilization for any other purpose is concerned. Any attempt to extract more heat from the gases as they escape from the boiler must result in a reduction of the draft. This inherent loss is, therefore, chargeable to any plant in which the draft is produced by a chimney, and possibilities in the way of increased economy must relate only to other losses so long as a chimney is retained. When the gases pass off at 500° and the excess of air is 100 per cent., this loss amounts to nearly 20 per cent. of the total calorific value of the coal.

Without going into the details of the calculation it may be stated that in the case of a chimney 100 feet high, having a cross sectional area of 10 square feet, the atmosphere being at 62° and the chimney gases at 500°, the actual work done per second in moving the gases is 1880.7 foot-pounds, while the mechanical equivalent of the heat expended to accomplish this result is 3 338 398 foot-pounds. Therefore the efficiency is

$$\frac{1\,880.7}{3\,338\,398} = 0.000563$$

That is, less than six ten-thousandths of the heat expended is represented by the work done, and this when no allowances have been made for work lost in friction. In practice the resistance of the chimney, the cooling of the gases in their passage up it, and other causes, combine to decrease even this extremely low efficiency.

If a fan be substituted, its efficiency must depend upon the efficiencies of the boiler, the engine and the fan, together with the loss by friction in the apparatus. If the combined efficiency of the boiler and engine be taken as one-tenth, the efficiency of the fan at only five-tenths and the loss from friction as two-tenths, or the efficiency as regards friction eight-tenths the resulting efficiency of the system will be

$$\text{Efficiency} = 0.1 \times 0.5 \times 0.8$$
$$= 0.04$$

This efficiency, which allows for loss by friction, as was not the case with the chimney, is

$$\frac{0.04}{0.000563} = 71.05$$

times greater than that of the chimney.

All other questions aside, the fan is, therefore, above question far more economical than the chimney. This economy means that surplus heat can be utilized and the gases reduced to a minimum temperature before they enter the fan.

In the production of draft by other means than the chimney, the steam jet is the only device which to any extent competes with the fan. The merits of the steam jet as compared with the fan must rest solely upon the relative efficiency with which a given amount of air is supplied, or as more simply measured, by the proportion which the steam required to operate the steam jet or fan bears to the total steam produced by the boiler in connection with which it operates.

Careful experiments, conducted at the New York Navy Yard, to determine the best form of steam jet for producing draft in launch boilers, served to show the inefficiency of such devices for this purpose. The results of five series of tests are presented in Table No. 19.

TABLE NO. 19.—RESULTS OF EXPERIMENTS UPON STEAM JETS AT THE NEW YORK NAVY YARD.

	Pounds of Water Evaporated per Hour.				
	A	B	C	D	E
In boiler making steam	463.8	580.0	361.25	528.5	545.00
In boiler supply steam jet	97.5	120.0	30.0	63.2	76.25
Per cent. of steam made as used in steam jet	21.20	20.70	8.30	12.00	14.00

The amount of steam required by a fan blower, as will be shown later, is under ordinary conditions from a fraction of 1 per cent. up to a possible maximum of 3 or 4 per cent. in small boiler plants or with uneconomical apparatus; and practically the whole of this expenditure of power, in the form of exhaust steam, may be subsequently utilized for heating or similar purposes.

* * *

THE greatest steam hammer of Germany is still the one called "Fritz," at the Krupp Works in Essen, but although great care had been taken in providing a very strong foundation, it has settled almost 16 inches. The construction of the foundation was started in a hole 40 ft. deep on a grill made of piling. Then there comes a deep layer of sawdust, upon which very large and heavy steel blocks solidly fastened to each other are resting. Next follow three alternate layers of heavy wooden planking and more steel blocks. On top there is a layer of cork 40 inches thick, carrying the anvil block, which weighs upwards of thirty tons. This foundation has to carry a total weight of about 2 300 tons, and in consequence of its settling, the hammer is but seldom used now, having been replaced by a hydraulic press able to exert a pressure of 12 500 tons. This hydraulic press is the largest at the present time in Continental Europe, England being the only country having one of the same size, at the foundry of Beadmore, at Parkhead. In this connection it may be interesting to note that the Bethlehem Iron Works have now a hydraulic press furnishing an equivalent of power of 14 000 tons pressure.—*Railway aud Engineering Review.*

HOW TO CALCULATE, DESIGN AND CONSTRUCT ELECTRICAL MACHINERY.—6.

Wm. Baxter, Jr.

The field magnets of electrical machines are magnetized either by the whole current that passes through the armature, or by an independent current, branched off from the armature current, or by a combination of both. The particular arrangement used will depend upon what the machine is intended for. In the case of generators of electricity, it may be desired that the current remain of constant strength, that is, of the same number of amperes; or it may be desired that it be of constant pressure, that is, of the same number of volts. The first type are called constant current machines, and the second, constant potential machines. The first are used for "arc" lighting, and the second for incandescent lighting, and for operating electric railway and stationary motors. Motors operated by constant currents are called constant current machines, and will not run at a constant velocity, with a variable load, unless provided with a governor similar to that used with steam engines. Motors made to run with a constant potential current are called constant potential motors, and may be made to run at a constant speed no matter how much the load may change, or they may vary the speed with variations in load.

Arc light machines, constant current motors and constant potential motors, intended for variable speed, are wound with their field coils supplied by the same current that passes through the armature, that is, they are in series with the armature, and are on that account called series machines. Constant potential motors, made to run at a constant speed, and generators made to develop a constant pressure, are wound with their field coils in parallel with the armature wire and are therefore traversed by a current that is derived from the main circuit but does not pass through the armature in the case of a motor, or over the line in the case of a generator. Such machines are called shunt wound. When it is desired to obtain closer regulation of, either the speed, in the case of a motor, or of the pressure, in the case of a generator, than can be obtained by the shunt winding alone, this is combined with the series winding, and such machines are called compound wound, if generators, and differential wound, if motors.

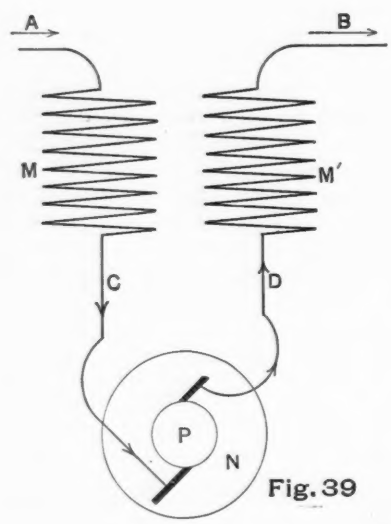


Fig. 39

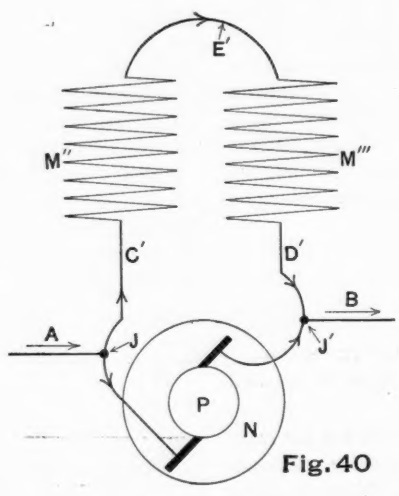


Fig. 40

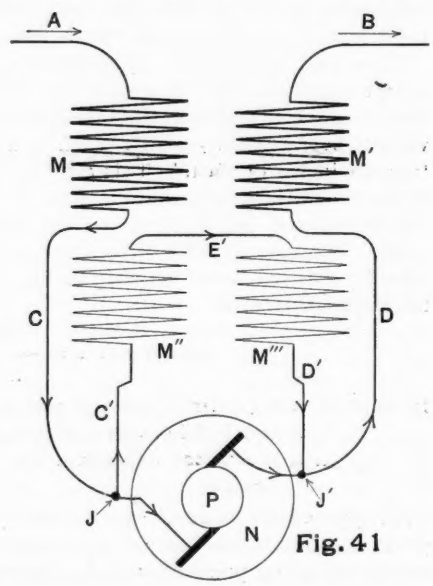


Fig. 41

Fig. 39 illustrates in a simple way the manner in which the electric current entering through the wire A, passes through the magnet coil M and then through the armature N, into which it enters by the way of the commutator P. After passing through the armature, it goes through the remaining field coil M^1, and thence to the wire B. Amateurs, who are not very clear as to the manner of making electrical connections, generally connect one of the brushes to either the wire A or B and pass the current through the armature first and then through the field. This arrangement amounts to the same thing as that here shown, so far as the electrical action goes, but does not look as well as when both line wires connect with field terminals.

Fig. 40 shows the simple shunt winding; from it will be seen that the current coming from wire A branches at J, part going through the armature, as in the series machine, and part through the field coils M^{11} M^{111}, the terminals of which are connected by the wire E. Both the armature and the field currents come together at the junction J^1 and pass to the wire B.

Fig. 41 shows the style of winding called compound, if used in connection with a generator, and, differential if in a motor. An inspection of the figure will show that the current from A passes through the field coil M as in the series winding, and then proceeds to the junction J where it splits, part going through the armature, and part through the field coil M^{11} as in the shunt winding. The current from M^{11} passes by the wire E to M^{111} and thence at junction J, just as in the shunt winding. At this junction it is joined by the current coming from the armature, and the two combined pass through the coil M^1 and thus to wire B. Sometimes the arrangement is changed by connecting the wires C D of the shunt coils to wires A B so as to shunt the coils M M^1 as well as the armature. The first arrangement is called the "short shunt" and the second the "long shunt." We will now explain how these different windings act, and how to calculate the dimensions of the coils to produce any desired result.

In the series winding, shown in Fig. 39, if the current increases the number of ampere turns in the field coils will increase and if it decreases, the ampere turns will decrease. Now as the E M F developed by the armature will change with any change in the number of lines of force in the field, it follows that this style of winding will cause the volts as well as the current, to vary. Such machines are generally used to generate a current that will remain constant if the E. M. F. changes, and to accomplish the result, some kind of regulating device is provided that is actuated by the strength of the current, and if the latter increases above the normal it cuts out a certain amount of the field wire, or else diverts some of the current through another path. As the regulating mechanism is controlled by variations in the strength of the current, it follows that it must increase or diminish the ampere turns in the field coils to such an extent that the E. M. F. developed will be just sufficient to keep the current strength at the proper point.

In the shunt winding, the current passing through the field coils will remain constant, so long as the voltage does not change, and the latter cannot change unless the current in the field coils change. If the armature wire had no resistance, the voltage could not vary, and therefore the field current would always be the same, and the machine would be perfectly self-regulating for a constant voltage. To force an electric current through a wire, however, requires an effort, as the wire opposes the passage of the current. As has been stated, the unit by which this resistance to the passage of an electric current is measured is called an ohm. It can be measured by means of instruments made for that purpose, but when such instruments are not at hand, it can be ascertained for all sizes of copper wire from the fact that all the manufacturers of wire print tables, showing the number of feet of wire of any size that is required to make a resistance of one ohm. The larger the wire the lower the resistance, that is, the greater the number of feet required to make one ohm. Now, by making the armature wire very large, and by reducing the

number of turns to the lowest point, so as to shorten the wire, the resistance can be made very low, and if this is done the voltage delivered by a shunt machine will be very nearly uniform. To make this point clearer, it will be necessary to say that the amount of current passed over a given resistance, will be in proportion to the voltage. For example, if the resistance is one ohm, an E. M. F. of ten volts will pass a current of ten amperes, and one hundred volts will pass one hundred amperes. Remembering this, suppose we have an armature with a resistance of one-tenth of an ohm, then if the current passes through that it is one ampere, and the E. M. F. required to overcome the resistance will be one-tenth of a volt; but if the current is one hundred amperes, the E. M. F. will be ten volts. If this armature belongs to a shunt wound machine that is capable of developing one hundred volts it will be evident that when the current is one ampere, the voltage delivered at the commutator brushes will be just one-tenth of a volt less than one hundred, but when the current is one hundred amperes, the voltage at the brushes will be reduced to ninety, because then it will require ten volts to overcome the resistance of the armature. Now, if the voltage at the brushes is reduced to ninety, the current through the shunt field coils will be correspondingly reduced, because the current will be impelled by ninety volts instead of one hundred. From this it is evident that if the resistance of the armature is reduced from one-tenth of an ohm to one-hundredth, the difference between the voltage of the machine when the current is strong, and when it is weak will be very much less. In this latter case, when the current is one ampere, the voltage used to overcome the armature resistance will be only one hundredth of a volt, which is practically nothing, and even when the current rises to one hundred amperes, the voltage used to overcome the armature resistance will only be one volt, and the E. M. F. delivered at the brushes will be ninety-nine volts, a difference of only one per cent. As this difference would only reduce the current passing through the shunt field coils by one per cent., the reduction in the lines of force passing through the armature would be next to nothing, and the voltage of the machine would be very nearly constant.

When a current is passed over wires to a considerable distance, a certain amount of the voltage is required to overcome the resistance of the line, hence the fluctuation in the pressure will be much greater at the receiving end than at the machine, providing the current changes very much in strength. To illustrate, suppose that the resistance of the line is five-hundredths of an ohm, then if the current is reduced to say ten amperes the voltage absorbed by the resistance will be half of a volt, but if the current is increased to one hundred amperes this loss, which is called the line drop, will be five volts. As a variation of five or six volts will cause a marked difference in the brightness of the lights, it is necessary to make generators for lighting purposes so that the voltage will increase slightly as the current increases so as to compensate for the line drop. To accomplish this the compound winding is used, and the way in which it acts is very simple. In addition to the shunt coils the whole current of the armature is passed through series coils, which also magnetize the field, (see Fig. 41). The effect of the shunt coils, alone, is to maintain the ampere turns about the same with any strength of current in the armature, but the series coils will add to the ampere turns an amount that will be in proportion to the strength of the whole current, therefore if the current passing over the line to the distant lamp increases, the ampere turns passing around the magnets through the series coils will also increase, and by properly proportioning the number of turns in these coils, the increase can be made such that the voltage of the current will rise as fast as the drop in the line increases, so that at the lamps the pressure will remain practically constant no matter how much the current changes. To illustrate how the proportion of the series coil turns is obtained, suppose the ampere turns in the shunt coils to be 5,000, and that this develops the E. M. F. required for the lamps if they were located near the machine, so that there would be little or no drop. Suppose, further, that the drop with the full load is five per cent., then we find out by the method already explained how many additional ampere turns would be required to develop this extra voltage, and knowing what the current in the line is at the full load, all we have to do is, to divide the extra ampere turns by this current, and thus get the number of turns that must be placed in the series coils.

In the generator, the series coils help the shunt, as their object is to further increase the pressure, but in a motor they act in opposition, as their object is to reduce the strength of the field, so as to prevent the speed from dropping when the load increases. It seems puzzling to some men that the field should be weakened to increase the speed of a motor, when the work it is called upon to perform is greater, but if it is remembered that the armature absorbs E. M. F. in proportion to the current that passes through it, it can be seen that the greater the load the greater the amount of voltage balanced in this way, and therefore the less left to impart motion to the armature. Now, as the field, if energized by shunt coils alone, will remain constant, the E. M. F. developed by the armature will be the same for each revolution, and, as when the current is strong, there will be less E. M. F. (of the operating current) to balance, a fewer number of revolutions will be required, and in order that the speed may remain as high as with a weak current, it is evident that the field strength must be reduced, so that each revolution will develop less E. M. F. On this account the series coils in motors are connected with the circuit so that the current will traverse them in the opposite direction, and thus by working against the shunt coils weaken the field as the current increases, and thereby maintain the speed constant.

The manner in which the number of turns in the series coils of differential wound motors is determined is just the reverse of that explained for compound wound generators, that is, we find out the number of ampere turns necessary to reduce the field strength to a point where it will develop in the armature the reduced E. M. F. required, due to the extra loss in the armature wire with the increased current, and having found this, we place in the series coils as many turns as are required to give this number of ampere turns with the full current.

The energy of electric currents is measured by watts, and as this unit is very small, another unit called the Kilo watt, is also used. This latter is equal to one thousand watts, and is used to designate the capacity of electric generators; thus a machine marked 100 K. W. is capable of developing 100 Kilo watts of electrical energy, which is the same thing as 100,000 watts. Such a machine may be able to develop any E. M. F. from the lowest to the highest, for, as has been stated, the voltage does not measure the energy, this being the product of the voltage by the current measured in amperes. From this it follows that if the E. M. F. is low the amperes will be high, and the latter will be low if the E. M. F. is high. If, in the machine above named, the voltage is 1,000, the amperes will be 100; if it is 2,000, the amperes will be 50; if it is 500, the amperes will be 200, etc. In rating motors it is customary to use the HP. as a unit, as this is better understood by the general public, and they can thus judge the capacity of the machine better. One HP. is equal to 746 watts, which, as will be seen, is just a little less than three-quarters of a K. W.

* * *

SPUR GEAR ARITHMETIC.—4.

Arthur B. Babbitt.

PITCH DIAMETER.

1st. Having given the outside diameter and the pitch to find the pitch diameter.

The distance from the pitch diameter to the outside diamete is $\frac{1}{P}$, as explained in formula

$$A = \frac{1}{P} \quad (4)$$

and as this is to be added on each side of the center, the outside diameter of the gear must be equal to the pitch diameter plus $\frac{2}{P}$. If this is so, then $\frac{2}{P}$ subtracted from the outside diameter will give the pitch diameter, or

$$D = D^1 - \frac{2}{P} \quad (15)$$

in which D = pitch diameter.
D^1 = outside diameter.
P = diametral pitch.

Example: A gear $3\frac{1}{6}$ inches outside diameter and 12 pitch to find the pitch diameter.

$3\frac{1}{6}$ inches (the outside diameter) $- \frac{2}{12} \left(\text{or } \frac{2}{P} \right) = 3$ inches, the pitch diameter of the gear.

2d. Having given the outside diameter and number of teeth to find the pitch diameter.

Multiply the outside diameter by the number of teeth and divide by the number of teeth plus 2.

We have shown in formula (5) that the outside diameter equals the number of teeth + 2 divided by pitch, or

$$D^1 = \frac{N+2}{P} \quad (5)$$

and in formula (3) that pitch equals the number of teeth divided by the pitch diameter, or

$$P = \frac{N}{D} \quad (3)$$

Now, if the outside diameter equals the number of teeth plus 2 divided by the diametral pitch (and the diametral pitch equals the number of teeth divided by the pitch diameter), then the outside diameter must be equal to the number of teeth plus 2, divided by a fraction with the number of teeth as numerator and pitch diameter as the denominator. This is simply substituting the value of the pitch as shown in formula (3) for the pitch in formula (5), and expressed as a formula, is:

$$D^1 = \frac{N+2}{\frac{N}{D}}$$

Multiplying both sides of the equal sign by $\frac{N}{D}$ we have.

$$D^1 \times \frac{N}{D} = N + 2 \text{ or } \frac{D^1 \times N}{D} = N + 2$$

and now, multiplying both sides by D, we have

$$D^1 \times N = (N + 2) \times D$$

and dividing both sides by N + 2 we get

$$(16)\frac{D^1 \times N}{N+2} = D \text{ or } D = \frac{D^1 \times N}{N+2}(16)$$

in which D = pitch diameter.
N = number of teeth.
D^1 = outside diameter.

Example: Given a gear $3\frac{1}{6}$ inches outside diameter and 36 teeth to find the pitch diameter.

$3\frac{1}{6}$ (the outside diameter) multiplied by 36 (the number of teeth) equals 114. 36 (the number of teeth) + 2 = 38. 114 ($D^1 \times N$) divided by 38 (N + 2) = 3 inches, the pitch diameter of the gear.

NUMBER OF TEETH.

1st. Having given the pitch diameter and pitch to find the number of teeth.

Multiply the pitch diameter by the pitch and the product wil be the number of teeth in the gear.

The diametral pitch of a gear equals the number of teeth for each inch of pitch; hence, if we multiply the diametral pitch by the number of inches of pitch diameter we will have the number of teeth in the gear, which, expressed as a formula, is:

$$N = P \times D \quad (17)$$

in which P = diametral pitch.
D = pitch diameter.

Example: Given a gear 3 inches pitch diameter and 12 diametral pitch to find the number of teeth. 3 (pitch diameter) multiplied by 12 (diametral pitch) = 36, the number of teeth in the gear.

2d. To find the number of teeth, having given the outside diameter and pitch.

Multiply the outside diameter by the pitch and subtract 2, or

$$N = (D^1 \times P) - 2 \quad (18)$$

in which N = number of teeth.
D^1 = outside diameter.
P = diametral pitch.

This formula is simply the reverse of formula

$$\frac{N+2}{P} = D^1 \quad (5)$$

If the outside diameter equals the number of teeth + 2 divided by the pitch, which we have already proven, then the number of teeth plus 2 must equal the outside diameter multiplied by the pitch, and subtracting 2 from this result we have the number of teeth in the gear.

Example: Given a gear $3\frac{1}{6}$ inches outside diameter and 12 pitch to find the number of teeth.

Multiply $3\frac{1}{6}$ (outside diameter) by 12 (the pitch) and we have 38, and subtracting 2 from this result we have 36, the number of teeth in the gear.

OUTSIDE DIAMETER.

To find the outside diameter having given the pitch diameter and pitch.

Divide 2 by the pitch and add to the pitch diameter, or

$$D^1 = D + \frac{2}{P} \quad (19)$$

in which D^1 = outside diameter.
D = pitch diameter.
P = pitch.

The addendum of a gear is $\frac{1}{P}$ (formula 4) and this, added on each side of the pitch diameter, gives the outside diameter.

Example: Given a gear 3 inches pitch diameter and 12 pitch to find the outside diameter.

3 (pitch diameter) plus $\frac{2}{12}$ $\left[\frac{2}{P}\right]$ = $3\frac{1}{6}$ inches, the outside diameter of the gear.

Having given the general principles of the proportions of gear teeth, we will now group the formulæ (which we have proven to be correct) under one head, so that they may be more easily found when wanted.

In the following formulæ,

P represents the diametral pitch.
P^1 " " circular pitch.
D " " pitch diameter.
D^1 " " outside diameter.
N " " number of teeth.
A " " addendum.
T " " thickness of tooth at the pitch line.
E " " full depth of tooth.
C " " distance between centers.
F " " clearance.

$$P^1 = \frac{3.1416}{P} \quad (1)$$

$$P = \frac{3.1416}{P_1} \quad (2)$$

$$P = \frac{N}{D} \quad (13)$$

$$P = \frac{N+2}{D^1} \quad (14)$$

$$D = \frac{N}{P} \quad (3)$$

$$D = D^1 - \frac{2}{P} \quad (15)$$

$$D = \frac{D^1 \times N}{N+2} \quad (16)$$

$$D^1 \frac{N+2}{P} \quad (5)$$

$$D^1 = D + \frac{2}{P} \quad (19)$$

$$N = P \times D \quad (17)$$

$$N = (D^1 \times P) - 2 \quad (18)$$

$$C = \frac{N+N}{2P} \quad (12)$$

$$A = \frac{1}{P} \quad (4)$$

$$F = \frac{.157}{P} \text{ or } \frac{A}{8} \quad (6 \text{ and } 7)$$

$$E = \frac{2.157}{P} \quad (10)$$

$$E = \frac{6.866}{P^1} \quad (11)$$

$$T = \frac{P^1}{2} \quad (8)$$

$$T = \frac{1.5708}{P} \quad (9)$$

This article simply treats of spur gearing. I will try and solve some of the difficulties of bevel gears in a later article.

* * *

THE Springfield Republican records the case of a man who devised an attachment for a machine which enabled one boy to do the work formerly done by four men, saving thereby $36. per week. The president of the company gave the inventor a check for $25. Comments are unnecessary.

* * *

ANGUS SINCLAIR, editor of Locomotive Engineering, contributes an article to the September number of the Pall Mall Magazine on American express locomotives. It is needless to say that the subject is well handled and that the article is in every way entertaining. In the very brief comparison that is made as between American and foreign locomotives, the author would appear to favor those made in this country, but he has the good sense not to make his opinions in this respect vulgarly prominent. The quite numerous engravings that accompany the article are produced in a style that reflects credit upon the well known periodical making them.

METHOD OF BORING LARGE CYLINDERS IN A 72-INCH LATHE.

ALFRED DUNN.

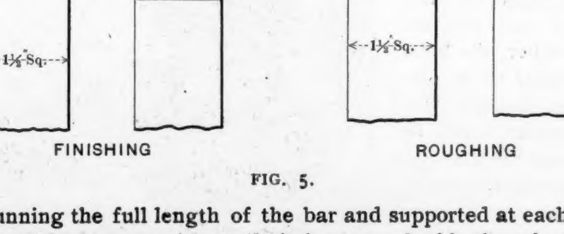
In the operation of making large pieces of machinery, there necessarily arises the question of how the work can be accomplished with the least amount of expense in the various departments through which the work passes before its final completion.

The following is a brief description of the methods used for boring and facing a 64" x 10' 6" cylinder at one setting by one of the foremost shops in the country. The machine in which the operation is performed is a 6' 0" Niles lathe.

Two parallel blocks with the slots in same for bolt heads are fastened securely across the ways of the lathe. Upon these blocks are bolted stands which support the cylinder by means of projecting feet and by which it is securely bolted to the parallel blocks as shown in Fig. 1. The head and tail stocks of the lathe are raised by suitable blocking pieces to suit the height of cylinder being bored. A 14" cast iron boring bar is used for carrying the head in which the tools are held.

The boring bar is driven by means of a socketed driving head into which it is securely keyed, and which is bolted to the faceplate of the lathe. To facilitate the centering of this driving head, a projecting piece is turned on same, which exactly fits the counterbore of the face-plate. To take the strain off the bolts two keys are fitted into the head diametrically opposite, and corresponding with two slots in the face plate.

The hub part of the head is spilt and has two bolts passing through bosses on same so that the bar can be clamped rigidly insuring uniformity of motion as shown in Figs. 2 and 4.



FINISHING ROUGHING

FIG. 5.

Running the full length of the bar and supported at each end is a 2½" feed screw with a ¼" pitch square double thread, which carries a bronze nut for moving the boring head longitudinally.

The nut is attached to the head by two circular projecting keys on same, which fit securely into two corresponding grooves in boring head as shown in Figs. 2 and 3.

The head is driven by two keys placed diametrically opposite each other and at right angles to feed screw, thus securing the least amount of friction between bar and head.

The head is composed of two pieces. The part next to the bar is 27" diameter and is one of a system of heads used for boring cylinders from 30" diameter and upwards. Securely attached to this head is a larger head 60" diameter which carries the tools and hard wood rubbers to prevent chattering of tools.

The tools are 4 in number of 1½" tool steel, and are held in slots in the face of the head by means of square eye bolts, as shown in Figs. 2 and 3. The hard wood rubbers fit tightly into slots on the periphery of the head between the tools, the back of the slots being made slightly taper to admit of adjustment.

The cutting speed for both roughing and finishing cuts is about 15 feet per minute which is slower than usual for cast iron, but a true hole is preferred to a quick job and the machine is not crowded. The roughing cut is about 3/16" deep with 1/16" feed, two of which cuts are generally taken.

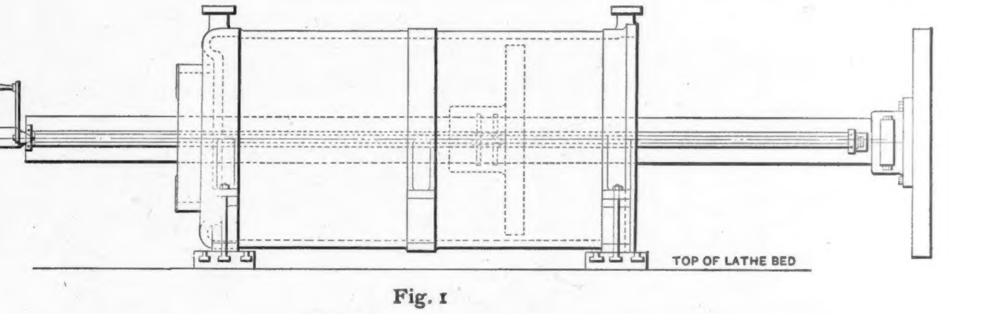


Fig. 1

The finishing cut is 1/32" deep with 3/8" feed. The shape of the tools used is about the same as in Fig. 5. After the cylinder is bored a facing arm is attached to the bar, and the ends of the cylinder are faced off, thus insuring a square job.

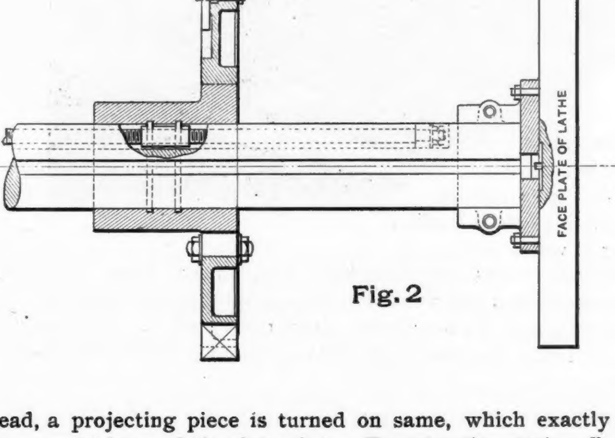


Fig. 2

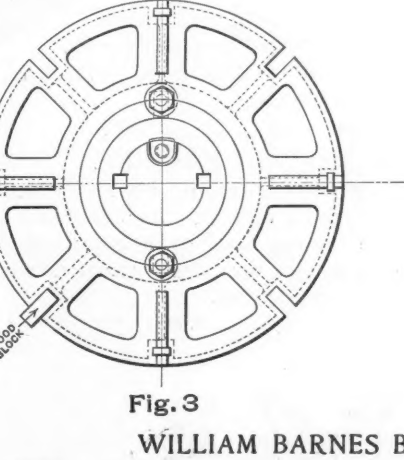


Fig. 3

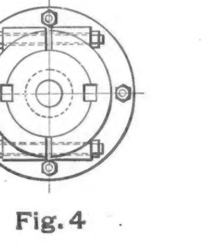


Fig. 4

WILLIAM BARNES BEMENT.

William Barnes Bement, one of the founders of the original company from which the firm of Bement, Miles & Co., of Philadelphia, has grown, died at his home in Philadelphia, October 6, at the age of 80 years. He was born at Bradford, N. H., and at an early age showed an inclination towards mechanical pursuits, which led him to enter an apprenticeship with Moore & Colby, textile machinery manufacturers at Peterborough, N. H. He became their superintendent at the age of 20 and later a member of the firm.

Undoubtedly the most trying experience of his early days was at Mishawaka, Ind., where he went with his family, only to find that the works with which he was to be connected had been burned. He had but little money, but through the skill which he displayed as a workman was offered the superintendency of the St. Joseph Iron Co., where he built his first engine lathe.

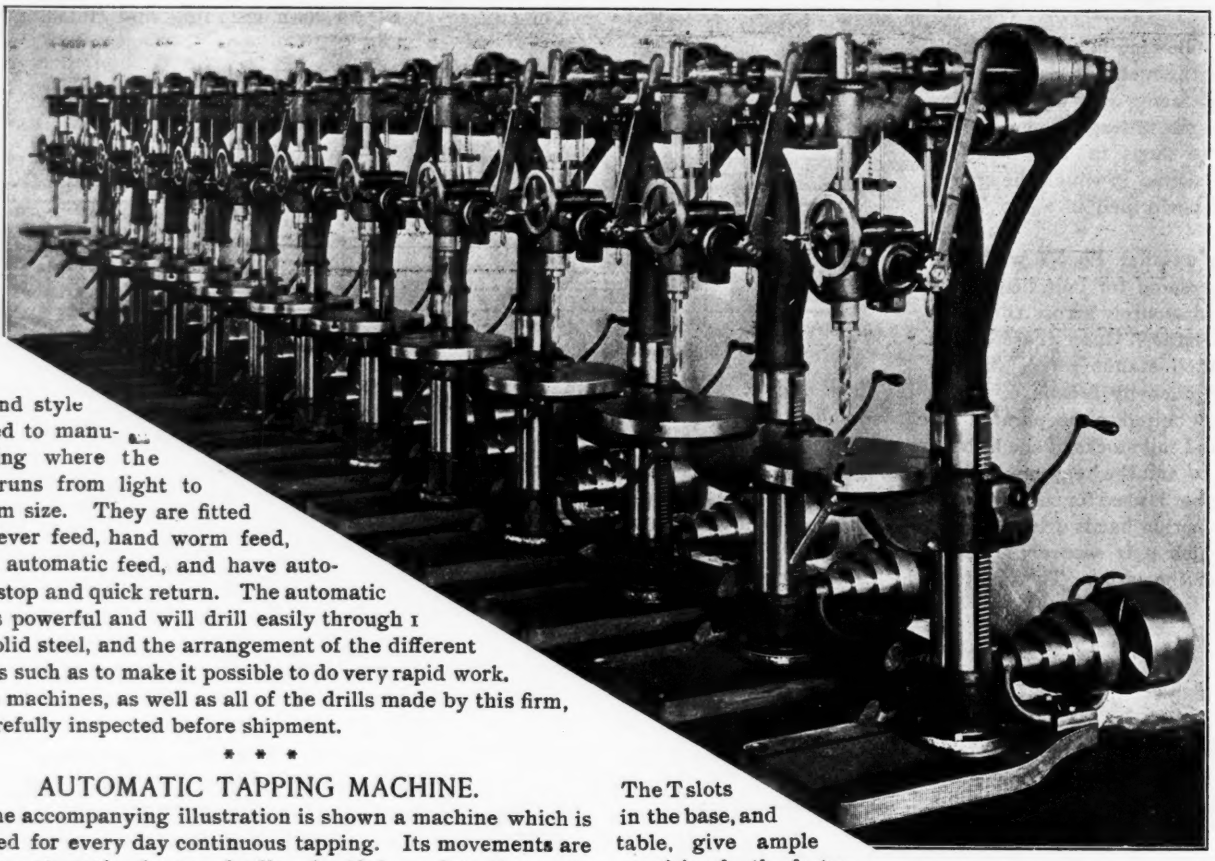
In 1851 he engaged in the machine business in Philadelphia, with C. A. Colby and E. D. Marshall. The concern built machine tools and was successful. Several changes have since taken place; among them the admission of Mr. Bement's sons, the purchase of the works of Frederick B. Miles, when the firm became Bement, Miles & Co., and the retirement of the elder Bement in 1888. During his retirement Mr. Bement has spent much time in traveling.

* * *

IT is said that the thrust exerted by a propeller exceeds by 40 per cent. the pull that would be exerted by a tow rope in hauling the vessel through the water at the same speed. The reason is that the water, not being a rigid body, is pushed back to a certain extent by the screw and the resistance required to accomplish this takes place, of course, at the bow of the boat.

GANG OF 20-INCH POWER FEED UPRIGHT DRILLS.

We herewith illustrate a line of 20-inch upright drills made by J. E. Snyder, Worcester, Mass., which are being manufactured in very large lots, both for home and foreign trade, and are of a

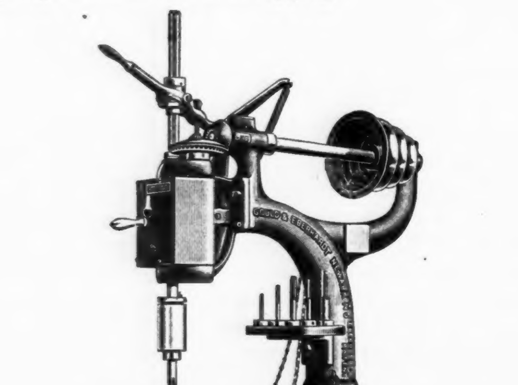


size and style adapted to manufacturing where the work runs from light to medium size. They are fitted with lever feed, hand worm feed, power automatic feed, and have automatic stop and quick return. The automatic feed is powerful and will drill easily through 1 inch solid steel, and the arrangement of the different feeds is such as to make it possible to do very rapid work. These machines, as well as all of the drills made by this firm, are carefully inspected before shipment.

* * *

AUTOMATIC TAPPING MACHINE.

In the accompanying illustration is shown a machine which is intended for every day continuous tapping. Its movements are entirely automatic, the tap feeding itself down into the work, and when through or to the bottom, reversing automatically and returning to position for the next tapping.



AN AUTOMATIC TAPPING MACHINE.

An automatic friction slip chuck prevents the breaking off of taps when bottoming or performing similar work. It also prevents the breaking of taps when from any cause they become fast in the work. This chuck can be instantly adjusted to suit work in hand. The machine will tap to the center of 36 inches, using taps from $\frac{1}{4}$ inch to $1\frac{1}{4}$ inches in diameter. The distance from the bottom of the spindle when up, to the base is 39 inches, and from the table to the bottom of the spindle is 16 inches.

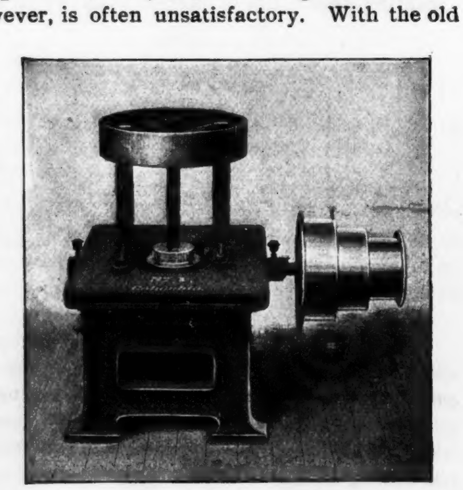
The speed of the spindle, when reversed, is much greater than when feeding, As the illustration shows, the machine is rigidly built, and is arranged for performing a large variety of work. The T slots in the base, and table, give ample provision for the fastening of work.

Eight chucks are furnished, with square holes to fit taps. Standard taps are used and no special taps are required. The net weight of the machine is about 1,000 pounds. It is manufactured under Eberhardt's patents by Gould & Eberhardt, Newark, N. J.

* * *

A REAMING MACHINE.

It is not an easy matter to ream a perfectly straight and true hole. When the work revolves and the reamer is stationary, the hole generally comes larger at the front end. Many overcome this defect by using a "wobble joint," allowing the reamer to "float," which, however, is often unsatisfactory. With the old (very old) method of reaming by hand, if the operator pulls heavier with one arm or the other, the hole is likely to be oblong, besides the irregular speed is damaging the cutting edges.



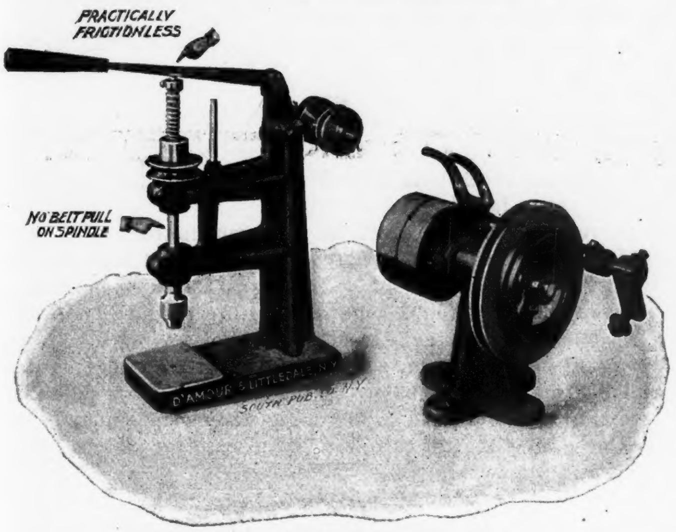
The accompanying illustration shows a reaming machine recently brought out by E. G. Smith, Columbia, Pa., designed to overcome these defects. Freedom of lateral movement is allowed, which ensures a true hole, and a uniform and not excessive speed is given to the reamer.

The reamer is driven by a worm on the cone pulley shaft working in a worm wheel on the vertical shaft which carries the reamer. The vertical shaft runs on a fixed step and the pulley

feeds down upon the reamer by its own weight. In ordinary practice it is found that it will do this satisfactorily if from 1-100 to 1-200 inch of stock is left. The two uprights are free to move in a straight line at right angles to the driving shaft and the pulley to be reamed is free to slide parallel to the shaft, so that it readily accommodates itself to the reamer without crowding to either side of the hole. The worm wheel is protected by a shield and suitable sockets are provided for the different sized reamers. Small work, such as collars, gear blanks, etc., may be held by a dog or carrier, the ends of which will be held by contact with the upright arms of the machine.

SENSITIVE BENCH DRILLS.

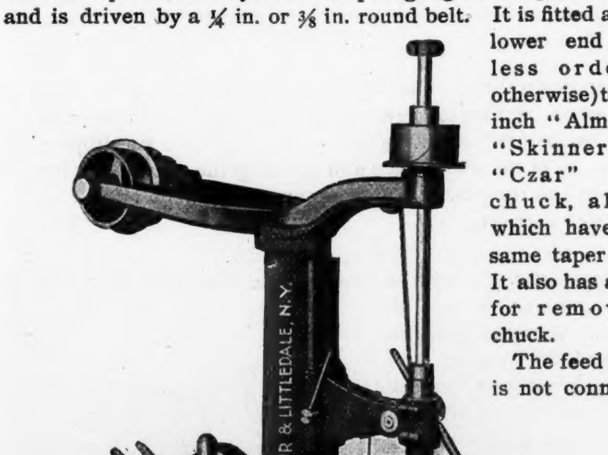
Two sensitive bench drills, one 8-inch and one 13-inch, have recently been brought out by D'Amour & Littledale, 204-206 East 43d St., New York. Both sizes are designed for light, sensitive and accurate drilling, are carefully made, in large lots, with special tools and fixtures for their manufacture.



8-INCH BENCH DRILL.

The spindle of the 8-in. drill is tool steel, 7-16 in. diam., and runs in cast iron bushings, which are adjustable for wear. It has two speeds, an adjustable stop to gauge the depth of holes, and is driven by a 1/4 in. or 3/8 in. round belt. It is fitted at the lower end (unless ordered otherwise) to 3-16 inch "Almond," "Skinner" or "Czar" drill chuck, all of which have the same taper hole. It also has a hole for removing chuck.

The feed lever is not connected to the spindle, but merely rests on it and is held to its highest point by the spring shown. The spindle is cone shaped and hardened at the top and makes contact with a hardened steel plate in feed lever, which is one of the most desirable features of the machine. The idle pulleys are adjustable to take up slack in the belt.

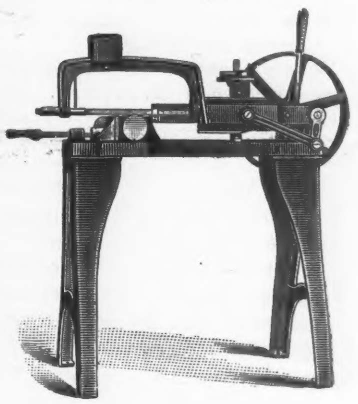


13-INCH BENCH DRILL.

The 13-inch machine will drill holes up to 1/2 inch in diameter. The spindle is made of hammered crucible steel as hard as can be worked. It is driven by a 1 1/4 inch flat belt, has three speeds, a cut steel rack and pinion feed, and an adjustable stop to gauge the depth of hole. It is entirely relieved of belt strain, and is counterbalanced by a weight inside of the frame which makes it extremely sensitive and uniform to the touch. It is also provided with means for taking up wear or lost motion, and is fitted to No. 1 Morse taper. The spindle head is adjustable to any position on column, and the table has a groove all around it to catch the oil. The countershaft is sent fastened to the frame as shown in cut, or separately if preferred, and the drill is built with either one or two spindles.

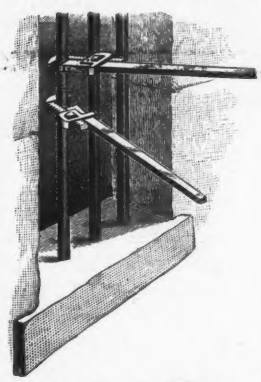
A NEW SHOP SAW.

The shop saw illustrated herewith has been put on the market by the Q. & C. Co., Chicago, Ill., to supply the demand for a cheap saw of small capacity, which, however, should not have the weak points of some of the old style machines. It will take 4-inch stock and will cut tool steel as well as other metals, being supplied with an improved gravity feed for hard metals of small size. The feed is automatic and variable and can be instantly changed without stopping the machine.



THRILLING, BUT PRACTICAL.

We do not suppose that the Walworth Mfg. Co., Boston, Mass., intend to have anything to do with the jail breaking business as a regular thing, but those who have read of the recent sensational rescue of the beautiful (of course) Miss Evangelina Cisneros from the prison in Havana, through the agency of a New York newspaper, will be interested in the part which this company played in the affair, as detailed in following press dispatch:



HOW IT WAS DONE.

This time there was no delay. Our outfit consisted of a pair of *Stillson wrenches*, and, putting one above and one below the cut made the night before, we wrenched the bar asunder with one snap. In a second I had caught the broken bar and had pulled it out enough for a purchase, and then slipping my knee under, I drew it up till it was horizontal with the roof. A second later I had twisted myself into a huge V above the crossbar, and, reaching down, caught Miss Cisneros by the shoulders and pulled her through the opening.—*N. Y. Journal, Sunday, Oct. 10.*

* * *

In discussing mechanical matters with a Russian engineer not long ago, the subject of oil grooves was referred to. He criticised our American way of grooving the bearing instead of the shaft, as is often the practice across the water. We are inclined to think that he has a good many arguments on his side, and that in this case, as in many others, we can learn a thing or two by going away from home. A splined shaft, like a feed rod, will run satisfactorily in a bearing, and if this gives no trouble, why should a shaft with oil grooves? It would seem that these oil grooves would carry the oil and distribute it over the bearing very effectually--much more so than the stationary grooves in the bearing itself. About the only thing that the grooves do in the main bearings of heavy engines is to fill up with dirt and the particles of babbitt that wear away as the shaft seats itself. Moreover, the grooves generally stay filled up, and that is all the good they accomplish. If this is true of heavy bearings, it must be true to a less extent of smaller ones. The same principle holds in both cases.

WHAT MECHANICS THINK.

THIS COLUMN IS OPEN FOR THE EXPRESSION OF PRACTICAL IDEAS OF INTEREST, TECHNICAL OR OTHERWISE. WRITE ON ONE SIDE OF THE PAPER ONLY, AND BOIL IT DOWN.

WHEN SKETCHES ARE NECESSARY TO ILLUSTRATE THE IDEA, SEND THEM ALONG—NO MATTER HOW ROUGH THEY MAY BE, WE WILL SEE THAT THEY ARE PROPERLY REPRODUCED.

For the best practical idea sent us each month to use in this column we will send a copy of Usher's "Modern Machinist," or Grimshaw's "Shop Kinks." For the next best we will enter a subscription for one year to MACHINERY to any desired address. For the next best, or for any idea that is worth publishing, we will send a copy of Colvin and Cheney's "Machine Shop Arithmetic."

ANNOUNCEMENT.

In this issue we print the second installment of letters which come under the premium offer at the head of this column. The first prize for the best idea in the last issue is awarded to "Some Way" for "A Rush Job," who is entitled to either "Usher's Modern Machinist," or "Grimshaw's Shop Kinks," as he prefers. The second prize of a year's subscription to MACHINERY is awarded to Fred E. Rogers for "Spherical Boring Rig."

Every mechanic who reads this has some idea worth publishing—most mechanics have several. Why not send them in and see how they look in print? Any idea, method, or "kink" which has helped you will help others. Let us have it!

WORKS OF REFERENCE ON MEASUREMENTS.

In your printing of the paper on "Standard Measurements" I see the works of reference were omitted, and send you herewith the list, for they are works containing a large amount of information regarding the history of work on standards, and would well repay one's time in reading them.

Quarterly Review, Vol. XXXVI, page 139; Vol. XXVI, page 416, *Westminster Review*, Vol. XVI, page 37. *Edinburgh Review*, Vol. LXXVII, page 121; Vol. XXX, page 501. Reports of the Committees on Weights and Measures, especially those of the House of Representatives, 1879 and 1896; Report of J. Q. Adams, Secretary of State, 1821; Encyclopedia Britannica, Weights and Measures; Johnson's New Encyclopedia, Pres. Mendenhall's revision of article on Weights and Measures; Report Secretary Treasury, 1857; Journal Franklin Institute, 1867, G. M. Bond.

W. A. VIAL.

Providence, R. I.

SQUARING NUMBERS.

On page 356 of your July number is a hint relative to squaring numbers. Why is not this more simple:

$$16^2 = 16 \times 10 = 160 + (16 \times 6 = 96)\ 256.$$
$$84^2 = 84 \times 80 = 6720 + (84 \times 4 = 336) = 7056.$$
$$87^2 = 87 \times 80 = 6960 + (87 \times 7 = 609) = 7569.$$

I cannot discern what your correspondent intends by this portion of line 8, "7520 add 72 = 49 and we have 7569." Where does the "72" come in?

ENQUIRER.

[The line should have read "add $7^2 = 49$."—ED.]

A FREE MERRY-GO-ROUND.

I was much interested in the article of October Number of your valuable paper, entitled "The Home of the Turret Lathe," especially in that part described as some old originals represented by figures 3, 8 and 9.

I served my time as an apprentice under the late Frederic Howe, in the machine shops of the Robins & Lawrence Co., at Windsor, Vt., and have worked many a day on the planers, index milling machines and upright drill presses. One particular incident in regard to the old drill press now at the Jones & Lamson Machine Company's, at Springfield, Vt., represented by Fig. 9, is vividly impressed upon my mind. One day I was passing the machine and I noticed a workman slowly revolving around, with his hands clasping the boring bar attached to the spindle of the press. There were four set screws in the socket that held the boring bar. The table of the press was down nearly to its lowest point and there was room enough for a man to stand upright between the table and the socket that held the boring bar.

One of the set screws caught in the man's necktie, and carried him round and round, with his hands grasping the bar and his feet dragging around the table. I was startled for a moment, but at once shifted the driving belt onto the loose pulley and helped the man extricate himself. After he was off the table and on his feet, I asked him how long he had been running there. He said, "For about five minutes." While he was rotating he never called out for help and probably would never have done so if he had run until he died, as he was one of those peculiar persons who think they can take care of themselves under any circumstances.

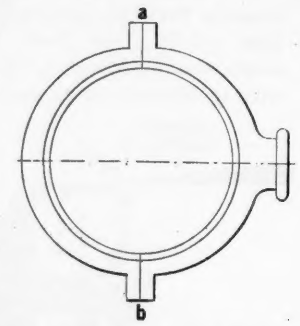
In regard to turret screw machines, the first I ever knew of being sold in the market was being manufactured by Moulton & Billings, at Springfield, Mass., in the year 1857. One of these machines can be seen at the present time in the shops of Smith & Wesson, in Springfield, Mass.

C. E. BILLINGS.

Hartford, Conn.

FINISHING WORK—BORING ECCENTRIC STRAPS.

When filing work in the lathe to polish I use a single cut lathe file that has been oil-stoned thoroughly from end to end. It cuts with a very smooth cut and does not pin, and leaves the work in excellent shape to polish. It leaves a nice finish if the work has been slightly oiled.



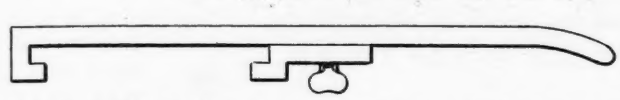
When boring eccentric yokes they always close in at the points *a b* when the stock is removed. I bore them to within 1-32 of size and face one side, then take apart and replane joint *a b*, then put together and chuck with finished side to plate; face to size, finish the bore and when taken apart, the yokes remain true.

C. F. A.

[The problem of boring eccentric straps so that they will not require an excessive amount of scraping on the sides, in order to relieve them, is a troublesome one, and we should like to hear from others who have different methods of solving it. In one shop that we know of, the eccentric straps are cast together and split on one side only before boring, which *ought* to relieve all internal strain; but as a matter of fact they trouble more or less by closing in, although care is taken to ease the clamps before the final cut is taken. ED.]

PUTTING ON BELTS.

I have seen a device, shown in the sketch, for putting on heavy and medium belts. It is made of machinery steel, 1¾ x ⅝ inches, and clamps on the rim of the pulley. The sliding part has a slot; the thumbscrew and the outer end of this piece is



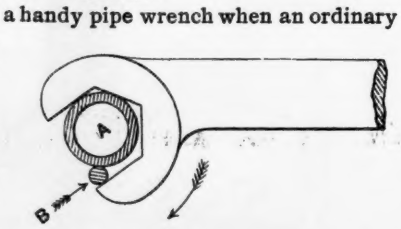
drawn down thin (not so shown in the engraving) so as not to slip when the thumbscrew is moderately tight. In using this device the belt is laid on the projecting arm, and by slipping over one edge of the pulley face and turning the pulley the belt will run on and the clamp can be loosened and taken off.

Rice's Landing, Pa.

WM. A. YOUNG.

A PIPE WRENCH.

Herewith is a sketch of a handy pipe wrench when an ordinary pipe wrench is not at hand. Between the pipe A and the jaw of the wrench is inserted a piece of old round file, B, broken off at the tapered end. It acts as a friction roller. It can be instantly released by turning in the opposite direction. It does not dig into the pipe nearly so much as the ordinary wrench in use will do.



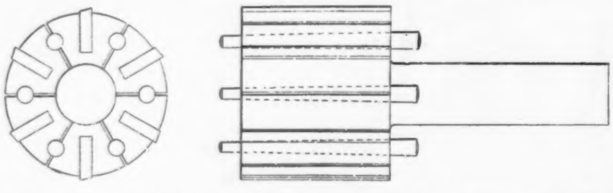
JAS. VANSTON.

REAMERS WITH INSERTED BLADES.

For making reamers I get genuine mushet steel, ⅜ x ⅛ inches, from B. M. Jones & Co., Philadelphia, and cut it up with a sheet iron or soft steel disc about 16 inches in diameter that I put on a Cincinnati Milling Machine Company's cutter grinder, running it about 3000 revolutions per minute. These pieces are for the blades and should be about 2 inches long for a 1½ inch reamer. I make the reamer body of shafting, say 12 inches long, the large end 1⅜ inches diameter and the shank 1 inch x 10 inches. In the larger end 6 plain, straight grooves are milled $\frac{9}{32}$ inches deep and ⅛ inch wide, to fit the blades, and if the latter are not tight they can be staked in. The reamer is then ground

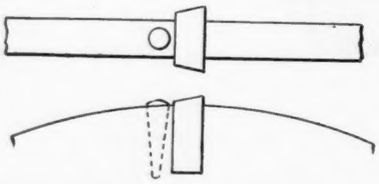
in the usual way, but in relieving the blades the bevel should not be brought quite to the edge; this method will prevent chattering. Of course, the points of the cutters are bevelled, and they should also project about $\frac{1}{16}$ inch at the end, which generally gives plenty of room for chips; but if more clearance is wanted, grooves can be milled in the body near the front of the teeth.

Larger reamers I make of cast iron and put in more blades; for adjustable reamers I mill the grooves shallower at the back



end and fit the blades in looser than before; then drill holes in the end between the teeth, ream them with standard taper reamers and mill saw cuts down through into the hole, as indicated in the sketch. Pins are then driven in. To adjust the blades, knock out the pins, slip the blades forward, grind them off at the end and regrind to size after driving the pins in again.

The advantage of mushet steel is very apparent and needs no explanation. I had occasion some time ago to mill a $\frac{3}{8}$ inch slot about 3 inches deep, and as my $\frac{3}{8}$ inch cutter was only about $2\frac{3}{4}$ inches diameter, I put a piece $\frac{1}{4}$ inch boiler sheet in the lathe and cut out an 8 inches disc, milled 4 slots in the periphery,

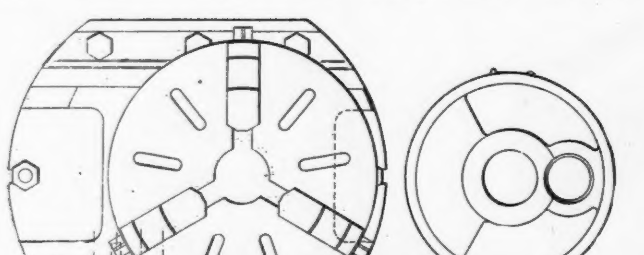


put in the musket steel teeth ground down and did the job. If I had much to mill with it I would have put in more teeth. If extra heavy work had to be done with it, I would grind a slight groove in the back of the tooth and drill a hole within $\frac{1}{16}$ inch of the slot, and drive in a taper pin without the saw cut; this would expand the boiler sheet into the tooth and hold it. I find that dove-tailed teeth cost several times as much and are no better that I can discover. HARRY GUNTHER.

San Antonio, Texas.

ECCENTRIC CHUCKING FIXTURE.

The device shown has worked well for boring two or more holes in fixed relation to each other at one chucking. On such work it forms its own jig. Crank discs, governor wheels with



hole for eccentric stud near bore, etc., are handled advantageously. Each position of the chuck brings holes in base and slide to register and the taper pin locks the slide. Small lugs shown on right of crank disc locate the work with reference to chuck jaw, and increase the latter's driving power. The stump in center of the base brings the fixture central with the hole in the table of the chucking machine, lathe face plate or vertical boring and turning mill, whichever it is used on. ROBT. S. BROWN.

New Britain, Conn.

CAMERA FIENDS WANTED!

Where are the machinists with cameras? Good, practical ideas, tools, jigs, machines or anything mechanical are more interesting and instructive when shown up with a photograph. We should like to hear from men who can do work of this sort.

A COMBINATION TOOL.

The combination caliper and divider shown is one that does not appear to be manufactured by any of the various tool companies. It is, however, one of the handiest that can be in a machinists kit, as it lends itself to so many varied forms, and often is capable of doing that which only a special tool can do.

Fig. 1 shows its use as an outside caliper, and it can be readily changed so as to be used on internal work. The common form of this tool has generally only one toe on the caliper legs, but the double toes save the reversal of the points when changing from outside to inside work.

Fig. 2 shows the divider points set at angle, which permits of stepping readily

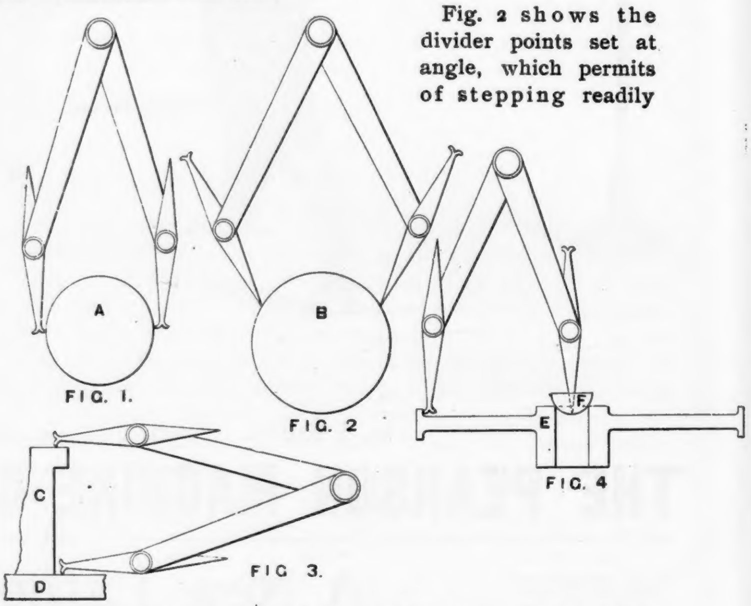


FIG. 1. FIG. 2 FIG. 3. FIG. 4

around the outside of a shaft at angular distances, where the ordinary dividers are useless.

A height gauge for planer work or similar jobs is shown in Fig. 3; D being the platen of planer and C the work.

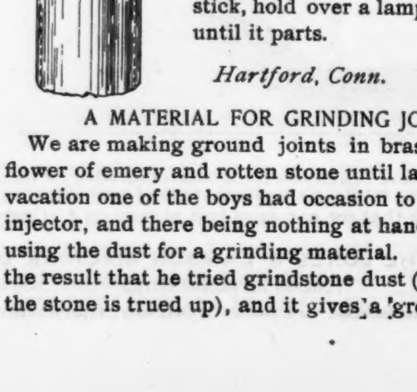
Fig. 4 illustrates its use in testing the truth of bored holes by having an auxiliary half sphere which has a taper hole fitting on one ot the divider legs.

A number of other uses could be mentioned, but any intelligent mechanic can readily suggest them for himself.

Corning, N. Y. FRED E. ROGERS.

SOMETHING FOR ENGINEERS.

The accompanying sketch shows an easy way to cut glass tubing when a glass cutter cannot be found, which is often the case. I find this way even better and surer than a glass cutter, as it avoids cracking lengthwise or flaking. Take a common parlor match, wet the brimstone end and rub it over the entire circumference outside and inside at the place to be cut. Make sure there is no broken space in the line the match leaves; place the tube on a stick, hold over a lamp or hot coals and turn until it parts.



W. C. HENSLEY.

Hartford, Conn.

A MATERIAL FOR GRINDING JOINTS IN BRASS.

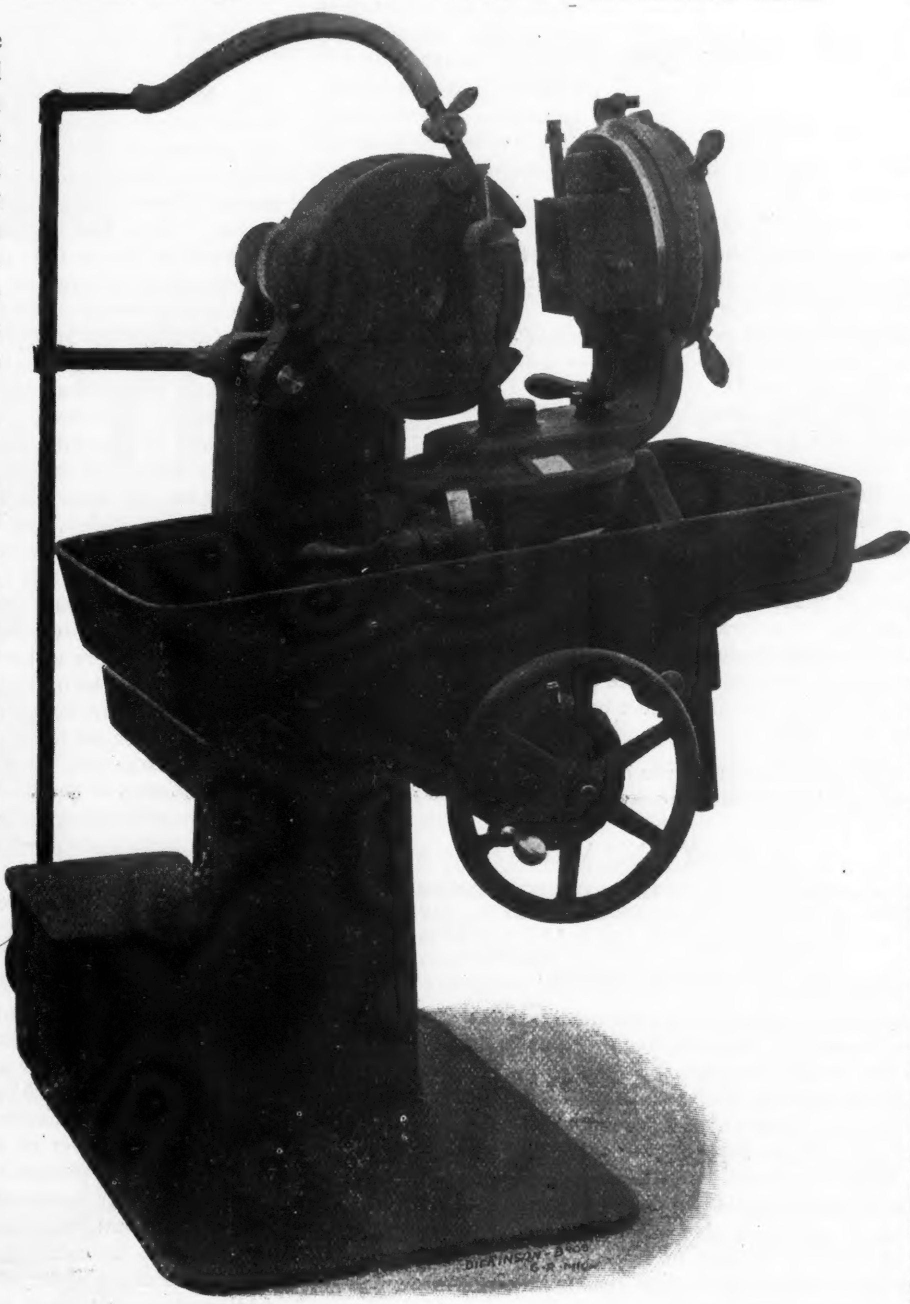
We are making ground joints in brass, and have been using flower of emery and rotten stone until lately. While away on a vacation one of the boys had occasion to regrind the valves of an injector, and there being nothing at hand, he powdered a brick, using the dust for a grinding material. He was so pleased with the result that he tried grindstone dust (the dry dust made when the stone is trued up), and it gives a great joint with no coarse

20% Saving in Labor BY USING THE

Gisholt Universal Tool Grinding Machine.

FOR GRINDING LATHE AND PLANER TOOLS.

Takes the place of the grindstone and emery wheel, and has many advantages which cannot be shown in an advertisement. A few are mentioned here.



The essential difference between this machine and the grindstone or common emery wheel is that the tool is rigidly held in a suitable holder while being ground. There is just as great an objection to holding the tool by hand while being ground as there is to holding it by hand in the lathe.

One method is as deficient as the other.

We claim the following advantages over any other system of grinding :

The machine tools can be kept continuously at work, instead of their being employed one or two hours less per day than the actual working time, which is the case when a man sharpens his own tool. Special grinder catalogue on application.

Tools are more efficient in operation because they are properly ground, and last longer at each grinding.

The actual cost of sharpening is less, to say nothing of machine tools being idle.

Tools last longer at each forging, because there is no waste in grinding.

Special tools are readily ground and duplicated.

One of our customers says : **"It enables us to keep our planers constantly in motion . . . at a rough guess would say that we get two hours per day per machine more work than we did before we had your grinder."**

GISHOLT MACHINE COMPANY, MADISON, WISCONSIN, U.S.A.

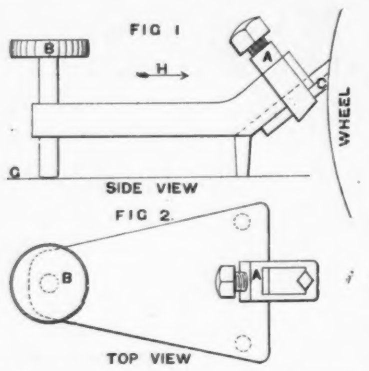
FOREIGN AGENTS FOR TOOL GRINDERS:

SCHUCHARDT & SCHÜTTE, Berlin, Vienna.
C. W. BURTON, GRIFFITHS & CO., London.
FENWICK FRERES & CO., Paris.
SELIG SONNENTHAL & CO., London.

scratches. I don't know that this is new to every one, but it is in one shop at least. APPRENTICE BOY.

TOOL-HOLDING DEVICE FOR GRINDING INSERTED CUTTERS.

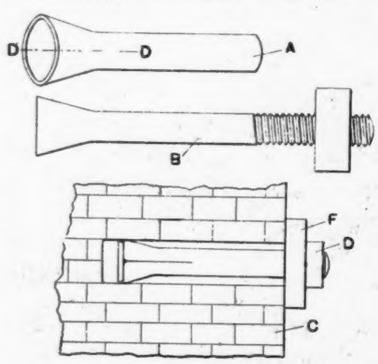
The sketch (Fig. 1) shows a device for holding cutters such as used in Armstrong and similar tool holders, and by its use the cutter can be ground to the exact angle every time on a common grindstone or emery wheel. It is unnecessary to go into a very complete description, as the sketches show the device very plainly, so that any machinist can easily construct it. A is the clamp for holding tool C, and B is a screw for adjusting the desired bevel or angle.



Angelica, N. Y. F. H. JACKSON.

ANCHOR BOLTS.

In the figure is an anchor bolt, used to fasten anything to a wall or floor. A is a piece of wrought-iron pipe heated and made bell-shaped at one end; it is then split a couple of inches at D, also at right angles to D. B is a bolt jumped at one end and threaded at the other; the length depends on the work. Drill the hole in the wall, so that the bell end of the pipe fits; put the bolt in the pipe and place both in the wall C. The work F holds the pipe from coming out, so that when you take up on the nut *d* the pipe will expand and wedge itself. These bolts are highly satisfactory.



Lawrence, Mass. J. T.

Do these letters interest you? Don't you think you could write one that would interest others?

HOW AND WHY.

A COLUMN INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST. GIVE ALL DETAILS AND YOUR NAME AND ADDRESS, WHICH WILL NOT BE PUBLISHED UNLESS DESIRED.

17. J. A. B. writes: From your answer to G. R. T., in the October number, in referring to the Prony brake, I understand that a line passing over the top of pin to a plumb line passing through the center of the shaft will be level. Am I right? *A.* Yes. We should have covered the matter better by saying that the arm should be horizontal, or at right angles to a plumb line; which it should be without reference to anything but the platform of the scale, which is supposed to be level.

18. A. R. writes: I have a boiler, the casting for the safety valve of which is flanged for the shell, the joint being what is known as a rust joint. This remained tight for about two years and then began leaking. Upon removing the casting for the purpose of making a new joint I found the shell eaten away, to a considerable depth, under the flange. The corrosion, or whatever it may be called, was quite regular and to an even depth. I had the joint renewed in the same way and now it has begun leaking a very little, the same as before. What is the cause of this and is there any way of remedying it? *A.* A rust joint should never be made between a cast iron flange and the shell of a boiler. Such a joint is a source of danger. The extremes of heat and cold, the dampness from the boiler and the material of which the joint is made, appear to combine, in a way which we certainly cannot explain, to continue the rusting indefinitely. No doubt if you continue making that sort of a joint long enough you will eat a hole entirely through the shell, or so nearly so that what little of the shell remains will be blown out. We should advise that you make a short neck casting with one flange to fit the shell, and the other flat, to fit the flange of a suitable safety valve case. Then cut a new hole in the shell, if necessary, a sufficient distance forward, or back of the old hole and rivet and calk the neck to the boiler, and patch the old hole. Either this or put in a new sheet in place of the damaged one and rivet the neck casting to this sheet. Top of this, mount the safety valve casting.

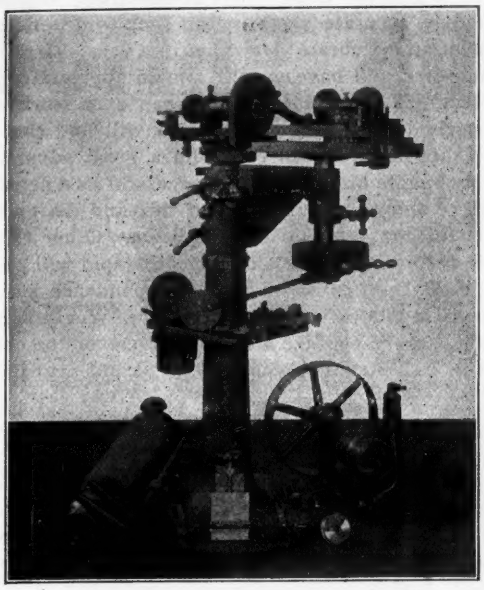
19. A correspondent asks us to recommend a composition for valves, cocks, etc. *A.* We have referred the question to a foundryman who states that the mixture given herewith is recommended for steam valves and that he has used it himself for water valves with good success:

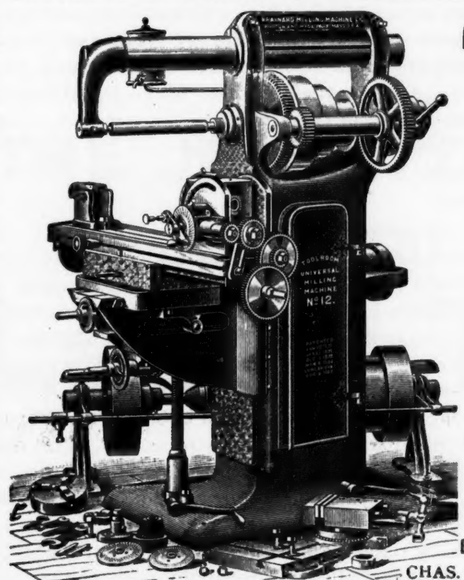
Composition.	Per Cent.
Copper	85.1
Tin	6.38
Zinc	4.26
Lead	4.26
	100.

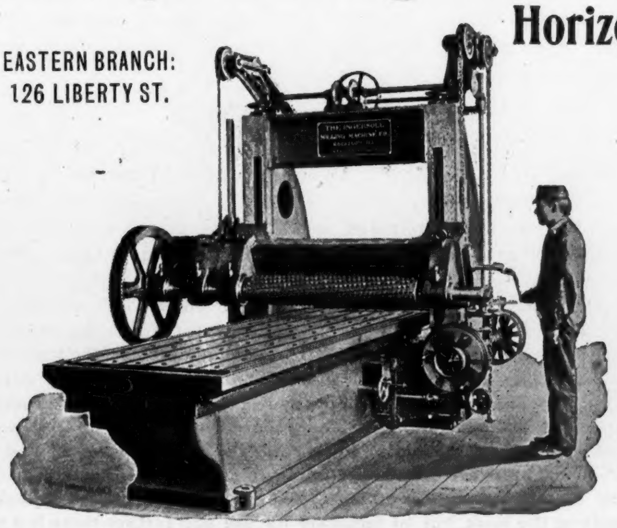
20. R. C. writes: I am running a 16-inch stroke engine at 200 revolutions per minute. For two-thirds of the time the engine runs as smoothly and as quietly as need be. For the other third of the time heavy machinery goes on and off and there is a succession of quiet running and heavy pounding. I have taken up all lost motion, but that does not appear to help very much. What puzzles me is that the engine, when moderately loaded, does not show the slightest inclination to pound, while if a little more heavily loaded it will pound whatever I may do. What is the reason of this? *A.* It is beyond much doubt insufficient compression. When the engine is lightly loaded compression is probably materially higher than terminal pressure. This operates precisely as any other cushion would act. If you were to strike a solid piece of iron with a heavy sledge there would be a strong shock, a rebound of the sledge and considerable noise. If now you put two or three cushions on the block of iron and strike them with the sledge, the force of the blow will be gradually taken up (absorbed) by the cushions, reaching the iron with little effect or noise. It is just so with the piston of a steam engine. If the pressure urging it forward is met by a sufficient pressure, from compression, before the termination of the stroke, this counterpressure will gradually increase up to the end of the stroke, the effect being that the momentum of the reciprocating parts is gradually absorbed just as the compressible cushions absorb the momentum of the sledge. There is no blow, and whatever lost motion there may be is gradually taken up before the termination of the stroke. On the contrary if compression is not so high as terminal pressure the momentum of the reciprocating parts is absorbed by a blow from the incoming steam and by the connecting-rod pins, main journals, etc. The lost motion is suddenly reversed, the sum of all these sudden transformations being jar and pound. The remedy in your case is to bring about higher compression.

21. J. P. A. writes: 1. An engine of 1 000 horse power furnishes power to five or six distinct departments, a different class of work being done in each. All the departments are in operation all the time. How can I determine, approximately, how much power each department receives? *A.* The best way to come at this approximately, and with the least trouble, is to first determine the power of the engine with all work off. Now throw on one department, taking three or four diagrams, then throw on another department, repeating the operation of taking diagrams. Continue in this way until all the work is on. You will be able, by calculating the diagrams, to determine very nearly how much power should be charged to each department, adding of course to each its proportion of the power required to run without load. This will give the approximate power required for each department. 2. What is the best modern work on steam engineering and indicator practice? *A.* For reasons that will be obvious to you after a moment's reflection we cannot undertake to name any book as the best. There are several good books on the subjects named; the most modern books are not always the best books.

22, H. J. D. asks: 1. How can I tell the horse power required to run any machine so that having several to run I will know how large an engine to buy? *A.* The only way to measure the power required to run a machine is by the use of some kind of dynamometer, an example of one being given in the October number of this paper. If you are to buy machines the manufacturer should be able to tell you the power required to run each. We shall publish more information on dynamometers in the near





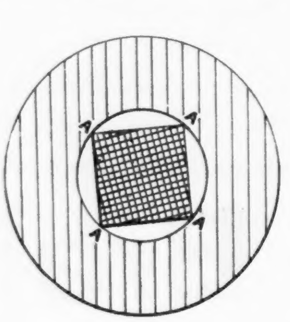


48' x 8' Machine.

future. 2. Why is it that well water is warmer in winter than in summer? I have seen it 53° in summer and 57° in winter. *A.* If you mean water from the same well we think you are in error, in taking temperatures. From some deep wells the water will vary but little in temperature as between summer and winter, but we think it is always cooler in winter.

23. T. J. asks: 1. Is gun metal made in the United States, and if so where? *A.* Gun metal is an alloy of copper and tin, to which a very little zinc is sometimes added. You can obtain gun metal castings from any brass foundry. 2. What material is best to use for a hollow cylindrical shell 1/8 inch thick and 4 inches diameter to run 8 000 revolutions per minute? *A.* Gun metal or some other good bronze alloy will probably serve your purpose. The cohesive strength of any good bronze is such as to afford a large factor of safety at the speed named. The cylinder should be turned inside and outside so as to be in accurate balance.

24. J. D. writes: What are the objections to the use of a square center for centering work in the engine lathe? The shop where I am serving my time is an old one and every latheman has his own square center. *A.* One objection to a square center is that it is not a cutting tool. An inspection of the angles at *a* will show that it is not in any sense, as it operates, even a scraping tool. Another objection is the shape which it almost universally gets ground into, as illustrated by Mr. Colvin in his sketch 8, Fig. 1, in the October issue. It is not fit for anything but roughing out centers. For this purpose our objection to it is that it is rough on the tail spindle bearings and on the slide and screw. This you can readily enough see when centering a rough shaft—say a hammered shaft—three or four inches in diameter, with a square center about as dull as they usually are, or even a sharp one.



25. M. A. L. writes: I have much trouble with my water line connections getting clogged with dirt. The boiler is the regular horizontal tubular, 5 feet in diameter. The lower pipe, which is the one that fills up, is 3/4 inch diameter and enters the boiler through the bottom of the shell. Can you give me a reason for its being troublesome? The water is rather dirty, but not particularly bad. *A.* There are two reasons for the pipe clogging, either of which is ample. The first is the pipe is not large enough. Make all the pipes, water and steam, 1 1/4 inches. Instead of entering the lower pipe through the bottom of the shell, enter it through the head and as near the bottom row of tubes as may be. Let the nipple or pipe extend through the head at least 6 inches. If the casting is tapped for the 3/4 inch pipe, tap it out 1 1/4 inch if there is stock enough; if not reduce right at the casting. Wherever there is a turn in this pipe use either a + or a T, so that an outlet, by unscrewing a plug, can be used for cleaning the pipe by the use of an iron rod. At the lowest point in the bottom pipe place a cock—which may be no more than 3/4 inch—and use it every day to blow out any mud that may accumulate in the pipe. Arranged as indicated, we should say you would have no further trouble. With connecting pipes clogged the water line is a good deal worse than useless.

26. S. A. W. writes: I have two shafts 20 feet apart. Power is transmitted from one of these shafts to the other by a 20-inch pulley on the first shaft to a 10 inch pulley on the second shaft. The first shaft runs 85 revolutions per minute. The pulleys have 8 inch face and an 8 inch single belt is used. This belt must be very tight to drive, and lasts but a short time. Would it help matters to use a double belt? *A.* It might help matters a little to do this, but a 10 inch pulley is rather small for a double belt. A better plan would be to use 40 inch and 20 inch pulleys. This would give you double the present belt speed, and the belt will drive twice as much as now, or will do what you want, drive twice as easily. If there is not head room for the larger pulleys, then use pulleys same diameter and face for a 16 inch belt, or better still, use 30 inch and 15 inch pulleys and a 12 inch belt.

27. S. A. P. writes: I am a machinist 21 years old, and have a chance to go into the draughting room of the works where I am employed. Do you think that a machinist can make a good draughtsman as a general thing? *A.* A machinist who has been accustomed to accurate work in the shop will generally learn to make neat and accurate drawings in a very short time, because his shop work will have taught him to appreciate nice work and to recognize the difference between such work and that which is poorly done. A machinist, also, will find that his familiarity with shop methods will give him a great advantage and will probably enable him to be very successful as a detailer. Whether he will be able to go further than this and design machinery will depend largely upon his education. Other things being equal, the better his education the more rapid will be his advancement. 2. Do you consider the correspondence system of instruction to be a good system? *A.* Yes. 3. Would it help me to advance if I were to take a course in one of the correspondence schools? I left school during the second year in the high shool. Yes.

28. E. L. H. writes: We are arranging a table of proportions of hubs, arms and rims for new gear wheel patterns; can you furnish us with any data bearing upon the subject? *A.* The following, which is taken from Wm. H. Thorne's course in drawing (published by Williams, Brown & Earle, Philadelphia), may form a basis to work upon; where "pitch" is mentioned, circular pitch is meant; that is, the distance from one tooth to another measured on the pitch line: Width of face, 2 to 2 1/2 times pitch; thickness of rim below the bottoms of the teeth, 5/8 pitch; depth of web below this about equal to the pitch, if the wheel has arms. Make width of arms at outer ends 1 1/2 to 2 times pitch, according to the number of teeth—say 1 1/2 times for 25 teeth and 2 times for 100 teeth. Taper the width of the arms from 11/16 inch to 3/4 inch per foot; thickness equal to .4 their width. Make the thickness of the web the same as that of the arms. In plate wheels, make thickness of plate about .6 pitch. The diameter of hub should be 1 3/4 to 2 times diameter of shaft; length not less than 1 1/4 times diameter of the shaft.

29. D. S. asks: Of what practical use are logarithms? *A.* By the use of logarithms the processes of multiplication, division, the raising of numbers to higher powers and the extraction of roots are greatly simplified, except where these operations are of a simple nature. Logarithms cannot be used for addition or subtraction. 2. I do not understand just what logarithms represent, and should be glad if you would explain them. *A.* The most common system of logarithms is based upon the number 10, as follows: 10 multiplied by itself, or $10 \times 10 = 100$. This may also be written $10^2 = 100$. Again, $10 \times 10 \times 10 = 1000$, or $10^3 = 1000$, and so on. In the first case the small number 2 shows how many times 10 must be taken to make 100; in the second, the 3 shows how many times 10 must be taken to equal 1000, and so on; and the 2 and 3 are called the logarithms of 100 and 1000 respectively. To illustrate further, suppose the logarithm of 200 was wanted. It is clear that 10 would have to be taken more than twice and less than three times to equal 200. As a matter of fact, it would have to be taken approximately 2.30103 times, and this number is the logarithm of 200. A logarithm of a number, then, is a number which shows how many times 10 must be taken to equal the first number. Elaborate tables have been prepared giving the logarithms of any desired number. Their use depends upon certain principles of algebra, which would require a great deal of space to explain.

FRESH FROM THE PRESS.

The Standard Electrical Dictionary. By T. O'Connor Sloane, A. M., E. M., Ph. D., author of "Arithmetic of Electricity," "Electricity Simplified," etc. A popular dictionary of words, terms and phrases, used in the practice of electrical engineering. Second edition, illustrated; 682 pages, 12 mo., $3.00. Norman W. Henley & Co., New York.

This work is in reality an abridged encyclopedia as well as a dictionary. The explanations and descriptions of the terms are so full that one who is not an electrical expert can understand their meaning, which makes the work much more valuable to the ordinary person. This new and enlarged edition has been thoroughly revised and an appendix has been added, bringing the subject matter up to date. It contains matter pertaining to Roentgen's latest discoveries and the electrical units are defined according to the standards established by the Electrical Congress of 1893. The terms are arranged alphabetically in the book, but to facilitate its use still further there is a very complete index. We believe that the book will prove valuable to any one who needs a convenient and general reference work on the whole subject of electricity.

MACHINERY'S EDUCATIONAL DEPARTMENT.

LOUIS ROUILLION, B. S., DIRECTOR.

HOW YOUNG MECHANICS CAN ADVANCE—A COURSE IN MECHANICAL DRAWING OPEN TO ALL SUBSCRIBERS TO MACHINERY AT A PRICE WHICH BARELY COVERS THE COST OF INSTRUCTION.

Since the inception of MACHINERY we have endeavored to present in every issue some matter of an educational character, written in simple language and intended particularly for those who have not received a technical education. These articles were in a measure only the preparation for an educational work which we have long had in view that will enable young mechanics, and others who so desire, to obtain personal instruction at home in certain necessary branches, and to acquire at a nominal outlay the knowledge necessary to obtain positions where they can earn more money.

This work has now been undertaken by MACHINERY without any expectation of profit, at a charge sufficient only to cover the actual cost of instruction and material required for the course, and will be under the personal charge of Mr. Louis Rouillion, widely known as a thoroughly practical instructor in both day and evening mechanical schools, whose warm interest in the cause of education has materially assisted us to begin the undertaking.

The first branch to be taken up, because of its greater value and interest to mechanics, will be Mechanical Drawing; but whenever a sufficient number of subscribers to MACHINERY express a desire to begin the study of any germane subject, we will then arrange a course of instruction therein.

HOW TO ENROLL.

Any one whose name is on the subscription list to MACHINERY is eligible to take a course in the Educational Department. To begin, it is necessary only to send us your name and address, with a money order for $2.35, in return for which we will forward you post paid the following necessary material:

	Price.
Text book on Mechanical Drawing	$1.25
Twenty instruction tickets	1.00
Thirty large printed envelopes, suitable for mailing the drawing plates; instructions, etc.	.20
Postage on the above	.10
Total	$2.55

The discount we obtain on the text book enables us to furnish the whole for $2.35. Those who do not find it convenient to send $2.35 can send us, instead, seven new subscribers to MACHINERY at $1.00 each. They must be new subscribers, not renewals.

THE DRAWING OUTFIT.

In order to do the work of the course properly, the student should have a good set of drawing instruments and other necessary materials. By purchasing in large quantities we are able to furnish the following outfit to those who desire it, for $3.40. When sent by mail, fifty-six cents must be added for postage, but to points near New York it can probably be sent cheaper by express. The weight is 56 ounces.

- Compasses, 5½ inches, with needle point; pen, pencil and lengthening bar.
- Drawing pen, 4½ inches.
- T-square, 24-inch blade.
- 45-degree triangle, 9 inches.
- 30 and 60 degree triangle, 9 inches.
- Scroll.
- Dixon's V. H. pencil.
- 12-inch boxwood scale, flat, graduated to 1-16 inch the entire length.
- Bottle of liquid India ink.
- Four tacks.
- Pencil and ink eraser.
- 20 sheets drawing paper, 11 x 15 inches.

These are not cheap instruments, but are thoroughly well made in every respect, with steel joints, needle points, etc., and the outfit would ordinarily cost between $6.00 and $7.00 in New York. We will not sell them to any person who is not on our roll of students. Those who do not find it convenient to send $3.40 can send us, instead, ten new subscribers to MACHINERY at $1.00 each, and the postage 56 cents, if they wish the set sent by mail. These must be new subscribers, not renewals.

A drawing-board about 16 x 23 inches will also be necessary; but as the expense of shipment will be considerable, students can usually make these themselves for less than we can deliver them for.

THE CORRESPONDENCE SYSTEM ADOPTED.

The correspondence system has been shown beyond question to be the best method for educating men who cannot afford the time and money to leave home and employment. By this system it is possible to furnish personal instruction to each student, which is much more efficient than that given at an evening school where one instructor has a large number of students and can spend but a few moments with each one. A student can also work as many hours or as few as he desires; he can work every day in the week if his duties permit, and he can advance as he is able without being held back by others who are less intelligent. On the other hand, if he is naturally backward he can go along slowly without feeling that he must work under pressure in order to keep up with his class; and he can ask questions privately by letter, which he would often hesitate to ask in the class-room where many of his associates might be more advanced than he.

METHOD AND COST OF INSTRUCTION.

When the student has secured his drawing instruments, book, and sheet of instructions, he can begin work at once, sending in the first plate for correction as soon as it has been drawn. The only expense in addition to the tickets and the cost of the materials will be the postage on the plates, which will amount to two cents per plate each way.

The course in Mechanical Drawing will comprise 29 plates, which are included in the text book we furnish. The student is required to draw each one of these plates in its order and to mail it to the instructor in the addressed envelope which we forward him, with one or more of the instruction tickets as may be required, and a stamped envelope for the return of the plate. The latter will then be carefully examined by the instructor, the errors pointed out and a letter written the student giving such instuctions as the work indicates that he needs. For convenience, we supply twenty tickets for one dollar, which are good till used on any course. One ticket each will cover the cost of correcting twenty of the twenty-nine plates; the remaining nine requiring two tickets each. Five of these double-priced plates come at first, and the remaining four at the end of the course. Each time that a plate is sent to the instructor to be corrected, the necessary ticket or tickets must accompany it. For special instruction on any point connected with the work the student must enclose one or two tickets for the reply, according to the amount of information asked for, together with a stamped return envelope.

DESCRIPTION OF THE COURSE.

The course in Mechanical Drawing will represent the result of a number of years' work with day and evening classes, mostly of working mechanics, by Mr. Rouillion. The text book used is published by L. Prang & Co., of Boston. It is a revision, with additions, of Mr. Rouillion's articles upon Mechanical Drawing which appeared serially in MACHINERY, and is regarded as the best short work on the subject.

The complete course includes 29 drawing plates, which ensure the student a thorough drill in the use of the instruments, projections, developments, and the general principles of mechanical drawing, besides enough practice on working drawings to enable him to make neat drawings and to read them understandingly. Particular attention is paid to lettering. The whole course requires about 300 hours to be completed by the average student, and we unhesitatingly pronounce it to be the best course in mechanical drawing that has ever been undertaken by the correspondence method.

Address, Educational Department, MACHINERY, 411-413 Pearl St., New York.

FRESH FROM THE PRESS.

Two notable publications come to us this month, which are not only fine specimens typographically, but reflect the enterprise of their publishers. One is the 25th anniversary number of the *Paper Trade Journal*, and the other the Niagara Falls number of the *Street Railway Review*.

Easy Lessons in Mechanical Drawing and Machine Design. **By J. G. A. Meyer. Arranged for self-instruction. Arnold Publishing House, 16 Thomas St., New York.**

We have received Part VII of this excellent work. The machine design section takes up the subject of slide valves and the proportions of steam-engine cylinders. In the mechanical drawing section, methods of representing sections are given and the subject of shade lines is explained. As usual, the whole is very clearly and fully presented.

Slide Valves. **By C. W. MacCord, Jr., M. E. A book for practical men on the principles and methods of design, with an explanation of the principles of shaft-governors. 168 pages with illustrations, 8 vo., $2.00. John Wiley & Sons, New York.**

This book is written in plain language and the explanations are so clear that any mechanic ought to be able to comprehend the subject by a careful study of its pages. Wherever formulas are used, arith metical rules are given also, and numerical examples are worked out in each case. In the chapters upon valve design, particular examples are taken and all the calculations are carried through. This method of treatment we believe to be the best possible in any text-book.

The subjects treated of are the principles and design of the plain slide valve, the double-ported valve and the Allen valve; equalizing the cut-off and admission, and exhaust and compression, by means of the rocker; setting the plain slide-valve; shifting eccentrics and shaft governors; and an analysis of the shaft governor.

The Zeuner diagram is used throughout, and of the treatment in general we have no adverse criticism to make; it is as good as we have seen and we can recommend it. In the governor analysis, it is clearly shown when, and under what conditions stability, unstability and isochronism exist and how any one of these three states may be avoided or brought about.

The main criticism that we can make of the work is of what it does not contain, rather than of the treatment presented. We regret that the author did not adopt a broader title and include more than a treatment of the slide valve, pure and simple. As many of the men who will purchase the book will be either engineers or draughtsmen, the former will be disappointed in finding nothing about the Corliss gear, the Stephenson link motion and double valves, with which any engineer is liable to have something to do, while the latter would naturally desire a still more complete work, like Peabody's or Spangler's, treating of many other types.

ADVERTISING LITERATURE.

THE STANDARD SIZES FOR CATALOGS ARE 9X12, 6X9 AND 3¼X6 INCHES. THE 6X9 IS RECOMMENDED, AS THIS SIZE IS MOST LIKELY TO BE PRESERVED.

LANDIS TOOL CO., Waynesboro, Pa. Catalog of universal and plain grinding machines. 24 pages, 6 x 9 inches. Round corners.

This is a catalog which we are glad to see, as it comes from the successors of the original company, which was burned out some time ago, and its appearance indicates that work is now proceeding regularly, as before. The full line of grinding machines made by this company, and with which our readers are familiar, is listed and illustrated, and the catalog as a whole, including the cuts, is an exceptionally fine specimen of work.

JAS. L. ROBERTSON & SONS, 204 Fulton street, New York. Catalog of the Robertson shaking and dumping grate bar. Illustrated. 16 pages, 5¾ x 9¼ inches.

This grate bar is illustrated in detail and views of important steam plants are shown where it has been used. We understand that this form of bar has given excellent satisfaction during a period of seven years. Other steam specialties made by this company are also listed in the catalog.

NORTON EMERY WHEEL CO., Worcester, Mass. Catalog of emery goods and grinding machinery. 112 pages, 5¾ x 8 inches.

This catalog lists and illustrates a new line of grinding machinery with countershafts, and a new bicycle cup, cone and hub grinder with magnetic chuck. We also notice that there have been improvements in the Walker universal tool and cutter grinder made by this company. Among the other tools and materials included are the Bath test indicator, and a full line of emery and corundum wheels.

THE JOHN M. ROGERS' BOAT, GAUGE AND DRILL WORKS, Gloucester City, N. J. Catalog of measuring instruments, reamers, hollow mills and rock drills. 27 pages, 6 x 9 inches.

It is very easy to produce a fine looking catalog if enough is spent on it to accomplish this result, but money is often spent uselessly, so that the manufacturer gets a cumbersome and inconvenient book, printed on paper that is entirely too heavy for the use intended, and representing in other ways money wasted. The Rogers' catalog is convenient to use, is printed on deckel edge paper and is a model of the printers' art. In addition to their usual products this firm has also just placed on the market a new Rock Drill, which is said by those who have seen it to contain many improvements over other appliances of this kind that have been in the market for some years. We believe that the firm will mail the catalog on request.

THE WATERBURY MACHINE CO., Waterbury, Conn., have sent us circulars describing their patent bench press for manufacturers of small jewelery.

THE HOGGSON & PETTIS MFG. CO., New Haven, Conn. Catalog of the Sweetland chucks, 56 pages, 4¾ x 7¼ inches.

Besides a description of the various styles of the Sweetland chuck it includes a few tools for machinists' use.

THE INTERNATIONAL CORRESPONDENCE SCHOOLS, Scranton, Pa., have issued a pamphlet containing 1,000 testimonials from students in every State of the Union, and in foreign countries as well. It will be sent to any address upon application.

MANUFACTURERS' NOTES.

THE Allegheny County Light Company, Pittsburg, Pa., has recently installed four Westinghouse engines of the vertical compound-marine type, each driving Westinghouse two phase 1500 K. W. generators. These are the largest steam-driven alternating current machines ever built and the engines are the largest to which alternating current machines have ever been direct connected.

L. E. RHODES, formerly of The L. E. Rhodes Company of Hartford, Conn., and prior to that with the Pratt & Whitney Co., has associated himself with the Davis & Egan Co., and will have charge of the department in which Lincoln millers, hand millers, etc., are manufactured. This company also report that they have received an order for tools for Krupp's Works at Essen.

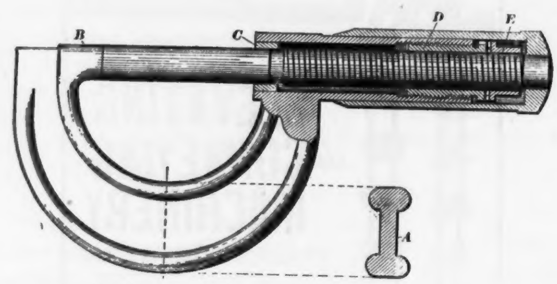
A. L. HENDERER'S SONS succeed A. L. Henderer, Wilmington, Del., manufacturer of hydraulic jacks and punches, pipe vises, tube expanders and boiler makers' specialties. Their New York store has also been moved to 123 Liberty St., from 112 Liberty St.

THE Blake Steam Pump Works, Boston, Mass., has added the largest Eberhardt's Automatic Gear Cutter ever built, for cutting spur gearing of the coarsest pitches, 100 inch by 20 inch face, weighing about 8 tons.

THE ADJUSTMENTS IN THE SLOCOMB MICROMETER.

Many mechanics will be interested in the accompanying sectional view of the micrometer manufactured by J. T. Slocomb & Co., Providence, R. I. The adjustments for both the wear of the screw and the wear of the anvil B are taken up in the barrel.

The adjustment for wear of the screw is effected by the main nut D and the adjusting nut E. These two nuts, D and E, are clutched together on their faces. There are 56 V shaped teeth milled upon the faces of each nut so as to fit each other. In order to adjust for looseness in the threads it is necessary only to turn the screw out of main nut D, then turn nut E one or more teeth ahead as may be required, the principle being something of the lock nut, except that the nuts do



not lock the screw. The arrangement allows of the adjustment being made in the direction of the wear, and does not bring new surfaces in contact, as is the case where the adjustment is made at right angles to the spindle. It also allows of using a solid nut, and avoids making any opening to admit dust or dirt to the screw. The adjustment commonly made at the anvil is made here by pushing the spindle endwise by the differential screw principle.

The main nut D is externally threaded to 32 P. (its internal thread being 40 P.) and is screwed (a tight fit) into the sleeve, which is a part of the main frame. The head of main nut D is slotted to fit a small spanner wrench, which accompanies each tool. It will be understood that upon turning the main nut D the spindle will be advanced or withdrawn, the amount of difference between the pitches of the external and internal threads. In this case the difference in a whole turn is 6 1-4 thousandths, so it will be seen that this tool has a very fine adjustment, it being a very simple matter to adjust to within the smallest limit ever required.

These micrometers are made in sizes from ¼-inch to 6 inches.—*Adv.*